

Qantary roofing  
slates

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Aswan -  
Buckingham Co  
Va

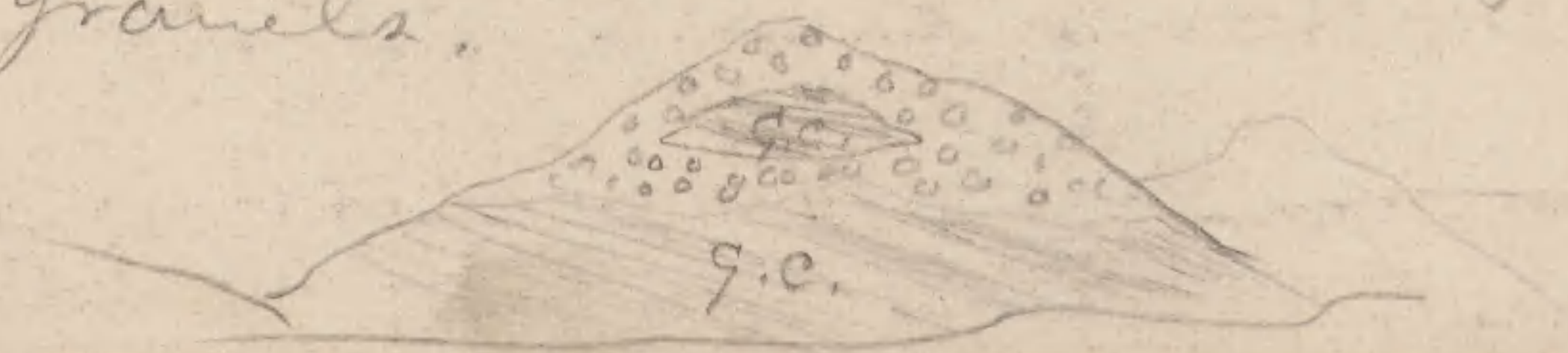
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Dec. 18/82. The accumulation of dirt, gravel & boulders on the slopes & in the lower portions of the upper canons of Mu-Ho-wi, Ku-a-gut & Chuan valleys are frequently of considerable extent & cover the underlying rocks except where a steep slope or the cutting down of the canon beds exposes them. Where, however, as is the case in Chuan valley, the hills have long been separated from the source of the debris, i.e. the higher canon walls & cliffs, erosion has gradually removed all this covering & left the clays & harder layers of the G. C. group in full view. There is evidence in all these valleys of a period when the drainage into the Colorado was at a higher level, during which time <sup>an</sup> immense accumulation of debris occurred. The lowering of the Colorado permitted of the lowering of the stream & canon beds & debris.



channels were cut dam thro' the masses of debris. Along the banks of the Colorado a similar deposit, much like many of the Quaternary deposits of New York state & the eastern side of the continent, shows that the river was dammed & backed up so as to fill in the channel 2 or 3 hundred feet. The debris of the valleys shows rock from the Larto. Red wall & Aubrey while that of the Colorado is much more composite in character owing to the varied sources of the material that dam by the river. In Chuan valley instances occur of a bed of gravel etc., having been deposited & over this a mass of the clays etc., of the Grand Canyon have slipped from above & again the gravel etc., has covered over it. Subsequent erosion has cut away the slope & left a point with the interbedded gravels.





Dec. 18/82

Section in Chuan Valley. Chuan g.h.

From drainage line (Stream) north. Midway of Valley.

(1)

l.

2.

1. Compact lead colored l-

2 ft.

2. Friable rather coarse gray to buff sd.

5-8

3. Gray l-in layers. 1 ft 2-6. (with a tendency to break up in shaly layers - separated by thin layers of clay shale drab + black. Layer of concentric l- 3' near base, looks like some Stromatopora form.

5-8

5-8

4. Dark clay shale

4-

5. " Shaly l-

1-

1-

6. Drab clay shale

4-4  
22-

7. The succession of clay shale + limestone with a few alternating beds of sandstone continues on up 500 feet when the l- layers become less + sandstone more abundant. No good line of demarcation can be drawn. In the 500 feet of beds 5 ft 6" of l- occurs as measured by rule. Section by level.

500-

54-6

8.

To this is added ~~775~~ <sup>625</sup> feet of clay + sandy shales with sandstone in narrow bands. The shales are usually chocolate brown, greenish + yellowish green.

A few limestone layers near the base + middle of the 29 feet of limestone.

625  
~~775~~ 1142  
~~1142~~

21.  
82-2

The strike + dip of the beds is given on the map.







	Book. Land.	1147	84-2
		<del>1297</del>	
1			
7 <sup>a</sup>	Shaly dark gray l- in massive layers.	2 ft	
2	dark clay shale	6"	
3	Shaly dark gray l- " "	3"	
4	Stromatopora limestone	4"	
	Contains fine specimens of this or a closely allied genus		
5	Alternating clay & sandy shales with layers of limestone.		
	Limestone 29'	310	29-
	Shales 28'	<del>289</del> -	113-2
		+ 325.	
8-	chocolate & dark clay shales with bands of brown & greenish sandy shales alternating from 5' to 25 feet & passing above into a brown sandy shale		
		<del>200</del>	
a	A band of Oolitic iron ore 2 feet thick occurs near the summit & traces of what appear to have been fossils.		
		300,	
8 <sup>a</sup>	massive layer of reddish brown sandstone separated in places by shaly sd.		1772
		25.	
8 <sup>b</sup>	thin bedded sd. with clay shale & a massive layer of sd. at summit		
		55.	1852
8 <sup>c</sup>	Sandy & clay shale, chocolate	40.	
9	massive stratum carbonate limestone. 4 to 6 feet		

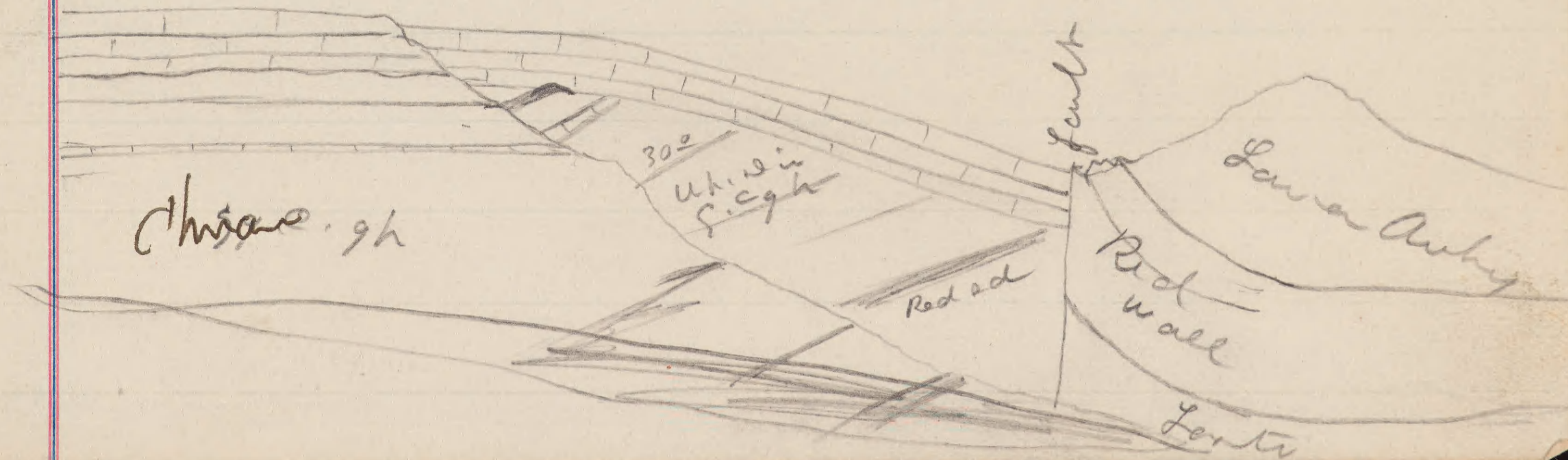
Ripple marks  
" "



The section continues on up thru' several hundred feet of 3  
the clays of the upper Chuan, but a synclinal axis  
and fault breaks it up & the red sandstone is a strongly  
marked boundary of the <sup>summit of the</sup> middle division of the  
group. The fault line <sup>in the</sup> Chuan runs along the south  
side of the ridge bounding Chuan valley on the north  
& drops the clays of the upper division of the  
Chuan 4 or 500 feet. The Lantz rests conformably  
upon them on the west end of the exposure &  
towards the divide (?) the l.c. beds dip westward.  
The cañon valley north of Chuan is sur-  
rounded by the Lantz with the Chuan, in sides  
& bottom to where it narrows to pass into  
the cañon leading to the river. In the lower  
portion of the valley the massive red sandstone

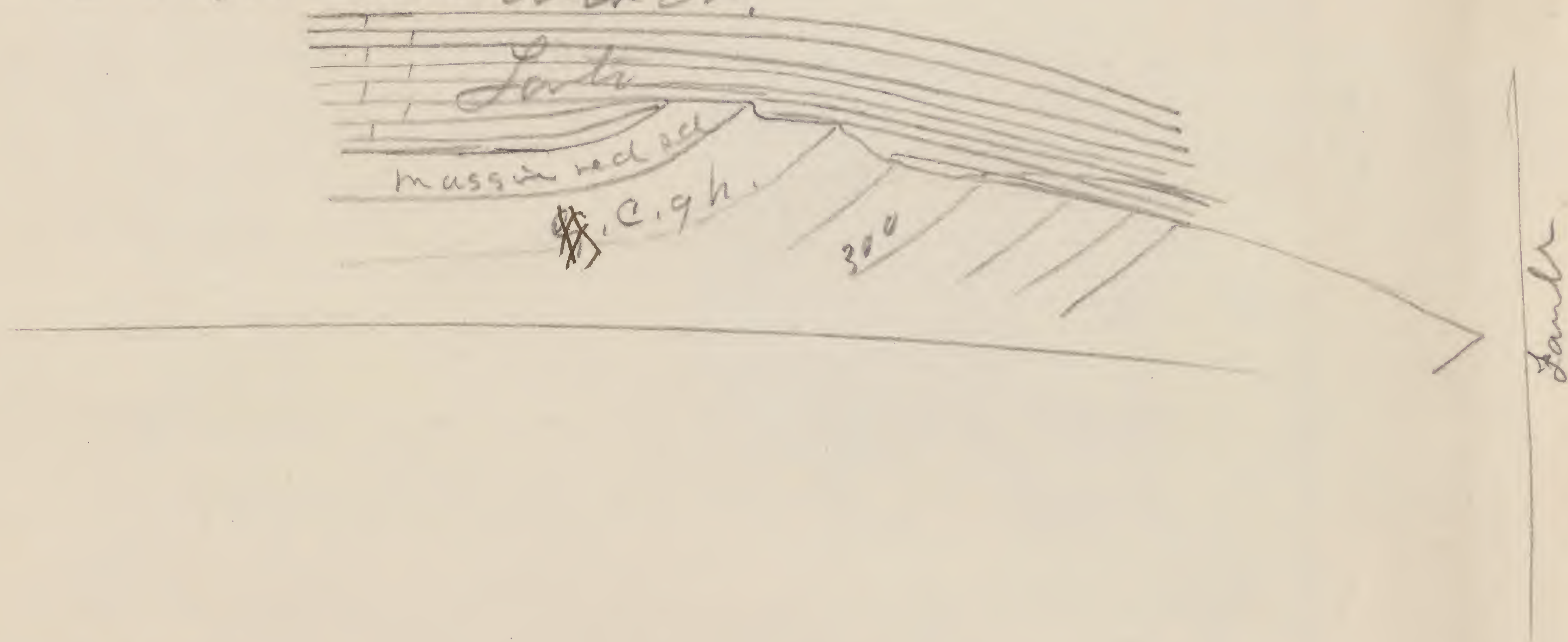


after the base of the upper div - ~~Chuan~~ crasses with  
 a N + S. strike & a westerly dip of 30° to 40°. Disappearing  
 under the Lente on each side N + S. In the  
 clays above, this dip rapidly disappears & the  
 red sd - capping ~~Shu~~ - Ho - weak butte & the upper  
 div - ~~Chuan~~ C. g. h. passes beneath the Lente as tho:  
 conformable in deposition. <sup>see back of page</sup> traces of erosion ham-  
 ping the base of the Lente a slightly undulating  
 line, N. side of Canton valley.





Just as it comes out at the end of a point it is level  
but on a cliff back further north it is seen to  
turn up as shown in the sketch. A closer view shows  
that its upturned edge formed a ridge & that the  
Tertiary was deposited over it.





The next two cuts north <sup>N.W.</sup> show the crossing of the red sd. (laver) & some of the clay shales above & below but debris covers the slopes & the exposure before the Lantz is quite limited.

Dec. 22<sup>d</sup> 1882.

Collecting lithological specimens & looking for fossils in the argillaceous shales of the ~~middle~~ <sup>laver</sup> division of the ~~Chaparral~~ <sup>Chaparral</sup> ~~group~~ <sup>group</sup> but did not discover any.

The upper division of the Chaparral is from the summit of New Konech butte to the massive red sandstone below. The ~~lower~~ <sup>laver</sup> div - is from that



down to the great sandstone series.  
 The upper div - is characterized by  
 the great development of clays, & the  
~~layers~~ by its clays <sup>shales</sup> & interbedded lime-  
 stones. ~~& the lower by its sandstones.~~

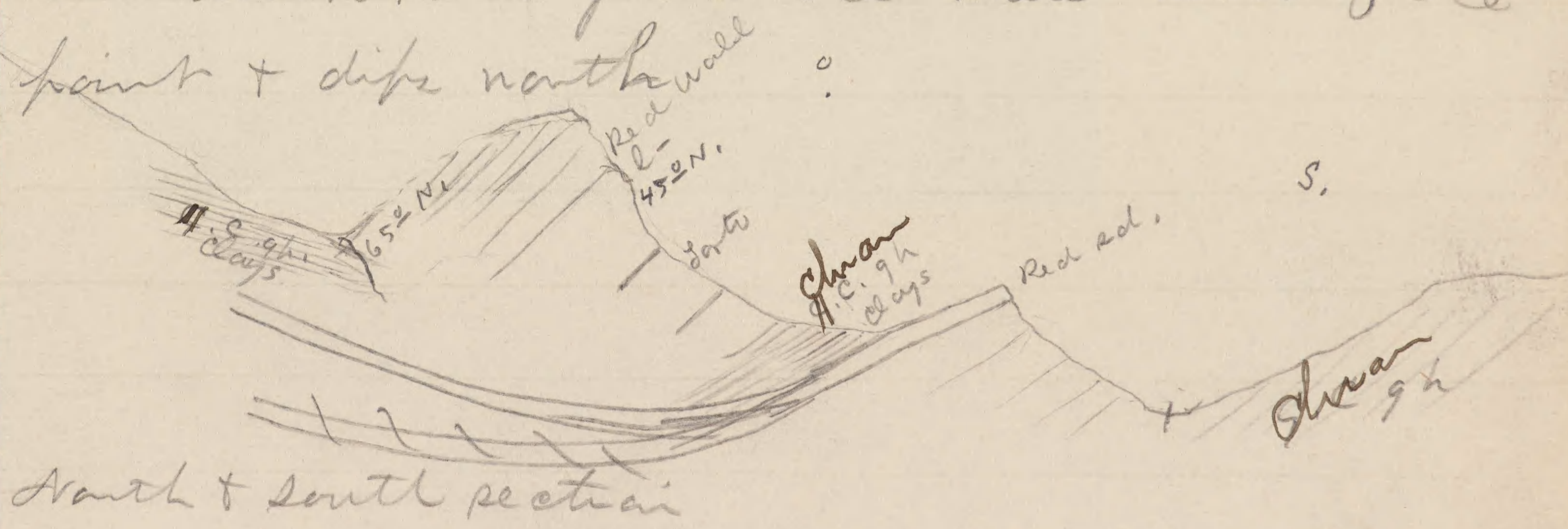
Dec. 23<sup>rd</sup>.

subsidence by erosion  
 SS.  
 In the N.E. side of Chuan valley, a point rises  
 which is cut off from the north wall of the valley  
 by a ~~deep~~ saddle & to the south a steep slope of 500  
 feet or more brings it out in strong relief. All  
 around its E. S. & W. base the massive red sd.,  
 capping the ~~lower~~ division of the ~~Chuan~~ dips  
 in towards it leaving it in the center of a bowl-  
 like depression. Over the red sd., the clays



& harder strata of the Chuan G.C. gh., dip in towards the point, where suddenly the massive sds., of the Lower Lonto gh., appear dipping north, <sup>35°</sup> these continue up about 200 feet when the limestones of the upper Lonto show thro' the debris & soon the base of the Red wall l- is met with. This forms the main mass of the point & dips northward.

Lonto cliff.  
G.C. gh







Section E + W. Thru the point.  
 Particular attention is given this point as it is an illustration of the effects of erosion & undermining of a harder formation & letting it down by a few degrees until from this cause alone <sup>by the steepness of the slope at the point</sup> they are dropped 1000 feet from their normal position in relation to the surrounding strata. During all this the <sup>we are</sup> has retained its bedding & the northward dip of from 35° to 65° is the only evidence



of its having been undisturbed & dropped little by little to its present position. The Butte<sup>#</sup> fault line is  $\frac{1}{2}$  mile to the east & the limestone & Lata of the point have evidently been lowered since the erosion of Chuan valley began.

<sup>#</sup> I call this the butte fault line as it has its inception on the north at the foot of the butte at the mouth of Hum-Ko-weah valley & extends along the west side of the six great buttes separating the valleys of Hum-Ko-weah Kwang-ut & Chuan from the Calanado Cañon proper & terminates on the south at the foot of the great south butte on the east of Chuan valley. It is not the true







Kai-bob fault, altho contemporaneous with the  
 " " uplift + fold but rather the line of  
 fracture <sup>along</sup> which the ~~Chuan~~ <sup>Chuan</sup> group was  
 forced up & from the stratum of the ~~Chuan~~ <sup>Chuan</sup> g.p., along  
 this line, beneath the Lento, it would appear  
 that there was a line of less resistance in  
 pre-Lento times (as in the time when the  
 present faulting occurred (butte fault).

### Pre-Lento land surface.

On the north<sup>E</sup> side of Chuan valley the Lento  
 curves gently down towards the butte fault  
 line. I had supposed this to be a part of  
 the Kai-bob fold but a close examination  
 of the underlying beds shows ~~that~~

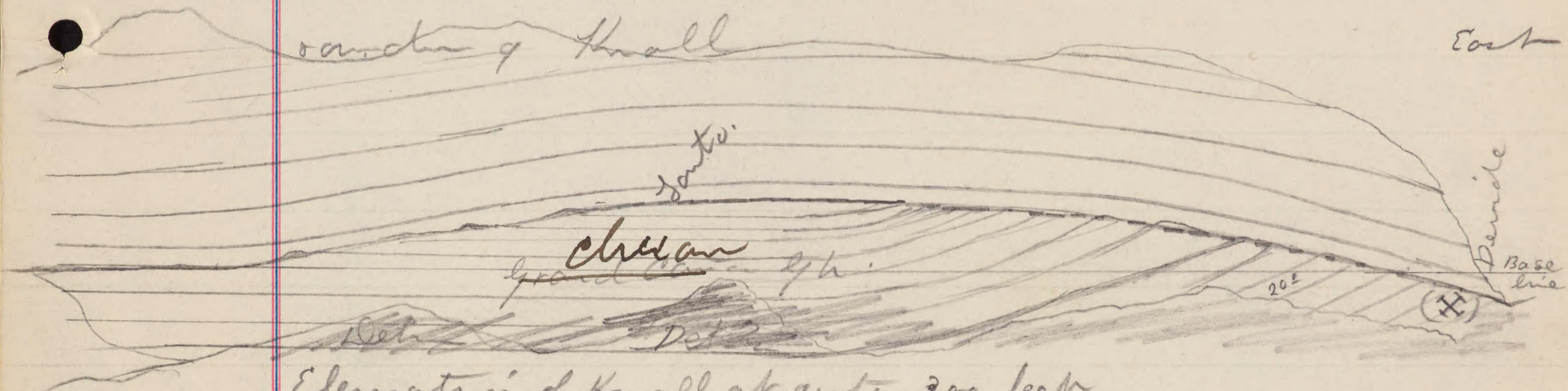
Section through  
 (At the base of the  
 Lento fault line)



west

no evidence of such a disturbance or fold  
but that the Lento is deposited over an  
sawdust of Knoll

East



Elevation of Knoll at center 300 feet.  
The beds at (X) show a little crushing but this is but  
a little distance from the fault line (but the fault).



Dec. 24", Merry Christmas

12

" 25". Went up one of the large N.C. canyons at the head of Chuan valley. After a dangerous climb reached the top of the Lanto & collected a few fossils. The shales & limestone of the lower half of the middle division of the ~~Grand Canyon~~ <sup>Chuan</sup> Gh. underlie the Lanto with a dip of  $1^{\circ}$ . This & the slight erosion of these beds is the only evidence of the unconformity. Nothing else of importance noted.

Dec. 26".

At the mouth of the north canyon draining Chuan valley into the Colorado. The base of the Lanto is 250 feet above the river & is underlain conformably by the upper strata of the ~~lower~~ <sup>division</sup> of the G.C. gh. Redish sd. with interbedded shaly bands. argt & anaceous.

The lower Lanto sd. preserves its characters & thickness as also the upper members of the group.

The conformity between the Lanto & G.C. ghs



continues up the narrow cañon leading to (13).  
 Chuar valley for some distance when  
 signs of unconformity begin to appear, one of  
 which shows the flexing of the g.c. g.h. beds  
 very distinctly.



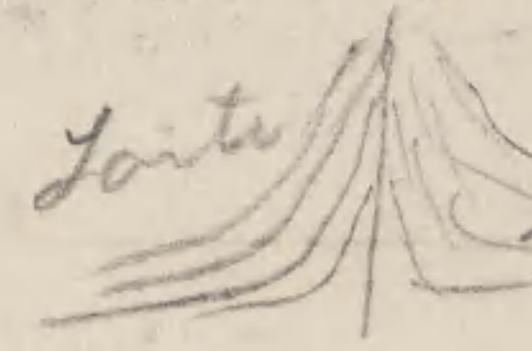
Butte fault line.

The cañon begins at the line of the Butte fault  
 line & the Lento sandstone beds are turned  
 up. Solid layers 18" in thickness coming out.







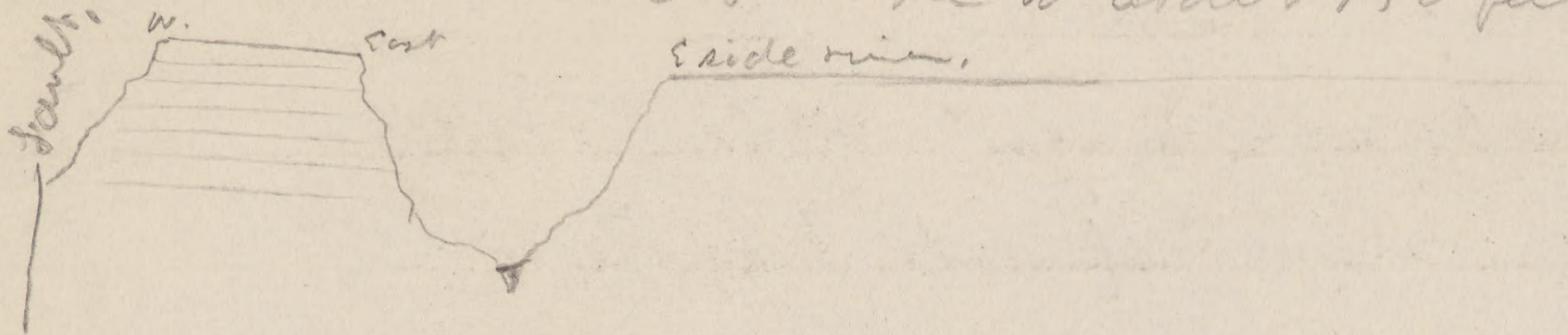
fracture. a little on the south the g.c. beds are seen turned up in the opposite direction  G.C. Beds.

Dec. 29/82. <sup>GS</sup> (In the lower cherty beds of the Red Wall I noticed numerous specimens of Levestella. Prodractus semineticulatus. Athyris subtilita. (mostly in the condition of casts in the chert.)

<sup>Levanan</sup>  
Beds of a similar character to those on the south side of Chuan valley occur on the north side on the most easterly spur. No fossils are here of uncertainty so doubtless they being the same. The summit of this point is about 100 feet above the level of the Plateau at the mouth of the little Colorado, and those of the high buttes rise about 300 feet above the



line of the ~~east cliff~~ summit of the ~~east~~ cliff of the Colorado  
on their west side & slope to about 150 feet on their east side.





Dec. 27"

Addition to section ~~Chuan~~ <sup>Chuan</sup> already taken in Chuan valley. Starting below & going up to base of other section. Notes p. 1

15  
Limestone

1. Massive band of irregular, thinly bedded limestone, gray & buff except near the summit where a chocolate tint prevails. This belt includes a variety of ~~layers~~ limestone
- a. Layers of hard compact gray l. - with dark calcification - like spots -
  - b. Very irregular calcification - many l. -
  - c. Thin shaly layers.
  - d. Evenly bedded thin layers of hard dead colored l. -
  - e. White, chocolate color

50, 50 ft.

2. ~~1.~~ Chocolate col. sd. shale .15
- b. " " passing into drab col. clay shale 40.
  - c. Ar + clay shales with interbedded thin layers of buff & choc. sd. terminating above in several thick layers of sd. 8 to 18 in. Ripple marks. Mud cracks. 55 110.
- 3.
- a. Greenish argillaceous shale 30 30
  - b. Brown sandstone in shaly & thin layers 20 20
  - c. Yellowish green & chocolate argillaceous & arenaceous shales. 195 195



Bratford -

- d. <sup>green, maroon, drab</sup>  
Chocolate, colored argillaceous shales with  
layers of thin bedded brownish sandstone 405 16  
50 ft
- e. Black & brown argillaceous shale with  
interbedded more or less friable  
sandstone in thin layers. 95. 180.
- f. Compact, lead colored limestone. 8 ft
- g. Six feet of shale, a layer of limestone  
like that of f. 5 feet of shale & another  
layer of ls 11 feet. & then a series  
of black & chocolate colored argillaceous  
& arenaceous shales succeed. 180 1.6 ft
- h. Compact, mottled, buff colored  
limestone 3 feet interbedded  
in 12 feet of brown sandy shale 15 3 ft
- Chocolate & greenish colored  
argillaceous & arenaceous shale  
with harder layers of thin  
bedded sandstone & seams & benches  
of white gypsum in some localities in  
the valley. 100. 975 ft 55 ft 4 in
- Black shale near  
quarry  
Next succeeds the limestones & shales  
of the section taken

See back.



In appearance the black shales are similar to those higher in the section. Thin bands <sup>2" to 6"</sup> of green, yellow drab & shades of brown are interbedded all thro' the lower portions of the this section. All the colored shales weather out in stranger tints than when in the beds & the black shales bleach to a dirty gray except when iron is present when they turn to a <sup>dark</sup> rust or a yellowish color.



## Chuan Valley

17

The strata of this section with that above to the massive red sandstone from the low sanding hills of the central portion of Chuan valley. A few faults of from 1 to 50 feet throw scarcely break the continuity of the outcropping edges of the harder layers of limestone & sandstone as they sweep around from the N.W. to the east side of the valley with the Carboniferous butte which rests in the center of the synclinal as their <sup>point</sup> ~~point~~ ~~which~~ they turn. The synclinal broadening out to the south, S.W. & S.E. from that ~~point~~. Any hard stratum may be followed for miles as its line of outcrop comes in & out around the hills & in the



shallow <sup>depression</sup> ~~running~~ between. Scarcely  
 or bush of any size grows on these hills &  
 all ~~foreign material~~ debris from the higher  
 cliffs of the Lanto & Cambrian has been removed  
 leaving the shales & harder rocks almost  
 entirely ~~marked~~. a little <sup>low</sup> sage brush &  
 bunch grass <sup>spotted</sup> the surface.

On the south side of the main drainage  
 line or ~~canyon~~ also immediately beneath  
 the Lanto cliff at the west & N. end of  
 the valley the slopes are covered with  
 debris & the strata of the <sup>Chuan</sup> ~~Grand Canyon~~ of  
 appear only in the deep steep washes leading  
 down throo the slopes.



~~About all this rises the~~ Added to this  
wonderful display of structure & stratification  
is the strong contrasting colors of the various  
beds of shale, limestone & sandstone. The deep  
dark red of the massive sandstone with its  
band of brownish red shales below, which  
are underlain by <sup>2990 feet of</sup> ~~the~~ variegated strata  
~~for 2000 feet.~~ Various shades of green, brown  
yellow, drab, buff with the rich maroon & pearl  
tints of the lower beds.

This forms the lower basin of the valley &  
above all around to the north, south &  
west rises the buff tinted sometimes reddish  
tinted lower <sup>sandstone</sup> ~~limestone~~ cliff, forming a wall.



separating the highly colored beds below from those above as the Lanto passes from dark to light green with a cap of deep red ~~stagnid~~ limestone which underlies the massive Red Wall limestone. Step by step or terrace by terrace the vermilion colored Aubrey sandstones with each terrace built out in relief by its dark covering of Pinon pine, leads up to the gray cliff of the Upper Aubrey limestone which shows a forest clad slope near the summit 3500 feet above the base of the Lanto.

Turning to the east two black, lava capped hills guard the lower end of the



valley & beyond rises the east wall of the Colorado cañon with its varied strata, 5000 feet above the river. At the interesting fault between the main valley system of Mu-Ko-we-sh, Ku-a-gut & Chien & the buttes standing between them & the Colorado a beautiful section is seen as also to the S. E. of the curvature of the Kai-bab fold beyond the <sup>termination of the</sup> fault line.

For evidences of the results of erosion the view is scarcely to be surpassed as a geological <sup>study</sup> & beautiful view of cliff & cañon scenery it is the finest ~~by all~~ that has yet met my eye either in nature or description, pictorial or written.



Dec. 29<sup>th</sup>

22

From the north the view of Chuar valley is quite unlike that from the south. The ~~semi~~ crescent shaped line of hills show their crests & the long slopes centering towards the butte resting in the synclinal, comparatively few edges of the strata can be seen & the entire surface of hill & slopes has the monotonous brown tinge & the debris covered slopes of the southern side unite with the lama hills at the north of the valley to give the entire scene a somber appearance. Even the great buttes on the N.E. look dark & the cliffs of the canon wall & Kaibab Plateau are



largely in the shadow of the afternoon sun. It is the canyon but not in its holiday dress. Even in the mists and steam it is more impressive the beautiful.

9.31

Debris.

The debris accumulated when the drainage line was at a higher level & now cut thru by the stream <sup>flashed</sup> channels is very compact & stands in a solid cliff sometimes 100 feet in height & great boulders project out many feet from the wall. Sometimes a flat rock has prevented the wearing away of the material below & it caps a column standing out from the main mass of the cliff.



Lento group.

H. side chert valley

The section of the Lento above the lower massive sandstone has deeper richer shades of green below & the summit is a stronger reddish brown than about Nun-Ho-mep. There is also much less limestone at the summit about 25 feet & the purplish colored sandstone just beneath this is thicker & with the reddish brown gives 150 feet.



Dec. 30<sup>th</sup>

25.

Out on long ridge overlooking Chuan valley from the next canon south. The ridge is capped with the Lower Tonto & underlain by the <sup>Chuan</sup> ~~g.c.~~ g.h. The view of Chuan valley is more extended than the one previously described but the details of color are not as well defined owing to distance. The synclinal with southern expansion <sup>the</sup> ~~concentric~~ butte is more extensively shown as all the <sup>covered by it</sup> ~~areas~~ visible at a glance.

To the south both the topography & geology of the lower levels differs. As steep ledges of dark sandstone



replace the rounded panti-colored  
 slopes & hills of Choon, \* Kwa-gust<sup>to</sup> valleys.  
 The Lanto sweeps around from canyon to  
 canyon with its mural wall below &  
~~sloping~~ <sup>smooth or</sup> terraced slope to the Red Wall  
 limestone above. The thin elevonian  
 formation is not appearing as a distinct  
 topographical feature from the upper  
 stratum of the Lanto.

Collected some elegant specimens of a  
 bilobed species of Cruziana in the middle  
 division of the Lanto. Between the massive  
 coarse s.d. below & the limestone above,



Jan'y. 17/  
1883.

Algonkian fauna  
Chesapeake

27

Looking for fossils in ~~Grand Cañon~~ gp. Only found in a dark bituminous limestone a few traces of vegetable matter. On many pieces of limestone fragments of arthrin incrustation look like broken bits of smooth shells but no regular form could be traced. Costs of mud cracks are very varied & abundant on the surface of the limestone, arenaceous and argillaceous layers. The uniformity in thickness & character of the different layers along an outcrop of several miles is a striking feature of the stratigraphy of the group.



1/2/83

Section at base of Chuar group.<sup>#</sup>

28

a Rests unconformably on massive beds of a rough  
partially metamorphosed limestone on the S. E.  
side of Chuar valley. These ~~masses~~ form a  
~~rough~~ rugged dark slightly arching  
a hillside with the shales of the Chuar g l  
dipping away from it on the north, N. W.  
& west. The unconformity between the shales  
and limestone is strongly marked. The lime-  
stone having been exposed to erosion prior  
to the deposition of the shales.

<sup>#</sup> As there is a distinct group below this in the Grand  
Canyon & this does not appear in the walls of the  
Colorado Canyon. The group as exposed in Mu-ke-  
meah, Hua-gant & Chuar valleys is called the  
Chuar group from Chuar valley where it is best exposed.



1/13/83

28<sup>a</sup>

In a more favorable locality away from the area near the latter fault line the change between the massive limestone & the clays above is merely lithologic & no unconformity is observed. Further study to the south is necessary before the unconformity can be disproved & the instance given on the preceding page ascribed to the action of the latter fault in disturbing the <sup>strata</sup> adjoining it.

The limestone at the summit is <sup>a</sup> still gray & reddish in color & partially crystalline. A fine exposure of the contact of this limestone & the Chuan group shows

1/14/83



that there is no unconformity between 286  
the two but from a careful study of the  
massive limestone I think it should  
be placed with the lower group.  
The Chuang begins above it. There  
is first at the base of the Chuang  
about 3 inches of argillaceous shale  
(a) then 6 inches of a hard compact  
fine grained gray limestone quite  
unlike that below & characteristic  
of the Chuang group. 3 or 4 feet of shale  
& another layer of similar limestone  
& then on up to the massive band  
of limestone shales continue, the  
clay shales



beds at the  
 The base of the shales are of a greenish color  
 that pass upward into drab. brown black &  
 higher a deep chocolate band of about six  
 feet is strongly defined in in the greenish  
 & yellowish colored shales and a similar  
 colored <sup>band of</sup> dark maroon occurs at the summit. Drab  
 greenish yellowish green & dark or brownish black  
 shales occur between. Considerable very fine  
 arenaceous matter is scattered thro' the shales  
 of this layer. 550 feet.

1/5/82

From the level of the Colorado river to Chino  
 valley where it narrows to pass thro' the lava  
 buttes is 225 feet. Locks level & Barometer. The  
 map gives these as 600.



1/5/83


## Butte fault.

30

The butte fault turns to the south east between Lempire butte & the north lava butte at the foot of Chuan valley & crosses the Colorado & dies out a short distance of a cañon coming in from the southeast, the strata forming a monoclinial fold instead of breaking.

## Pre-Lento fault.

The old fault line during Pre-Lento times ran along this line but it <sup>also (or a branch)</sup> continues on to the south crossing west of the lava buttes of Chuan valley.

All along the butte fault the strata on each side turn up towards the fault  but on the

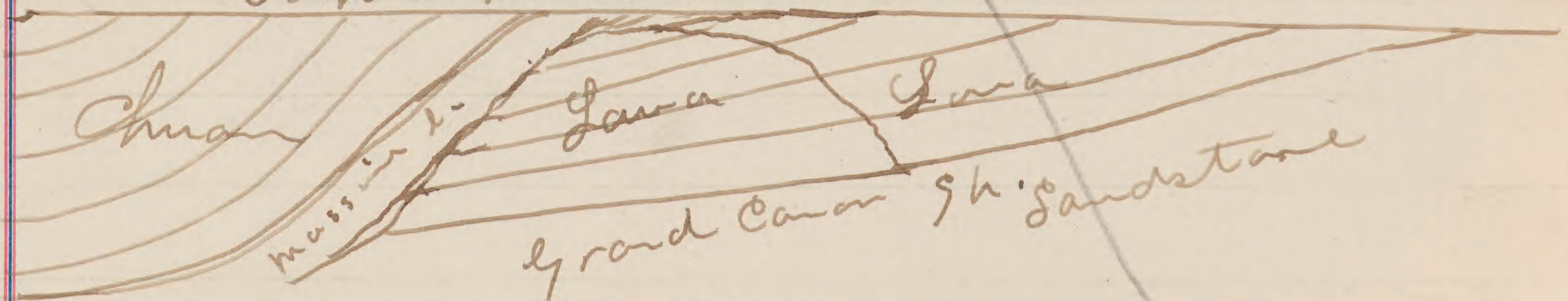


31  
Pre-Tonto fault only to the east. This offers  
to explain the peculiar character of the  
little fault as seen in cross section.

The original Pre-Tonto fault had the  
downthrow to the west & the beds  
dragged on but ~~up~~ to the east.



leaving the land surface in this ~~wise~~  
at the time of the deposition of the Tonto  
Surface for Tonto.

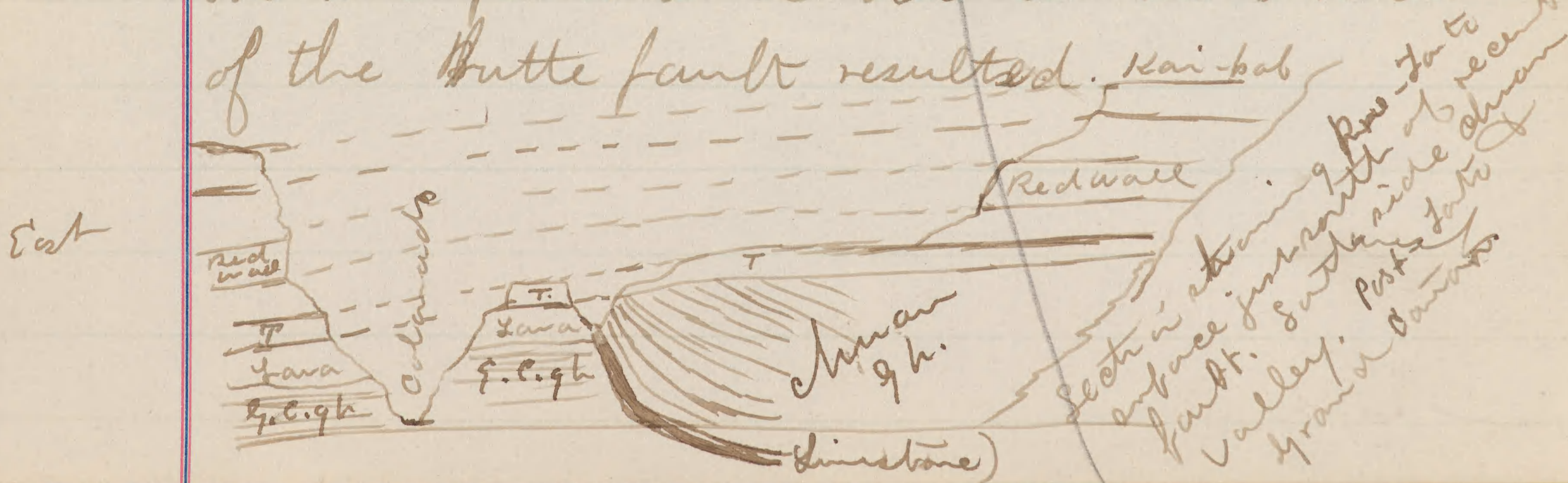




where the lava and sandstone on the <sup>32</sup>  
east side pushed up bending the more yielding  
beds above to the west. Over the Pre-Tertiary  
surface appears to have been planed off by  
an advancing ocean line as there are no  
canyons or other strong evidence of aerial  
erosion the slight undulations of the surface  
being scarcely perceptible at a moderate  
distance. The Tertiary & other Palaeozoic groups  
were then deposited with but little move-  
ment along the ancient fault line, as also  
the Mesozoic & probably Tertiary strata. When  
however, the Kai-fu uplift manifested  
itself a line of weakness already existed  
in the Pre-Tertiary strata & along this line



the strata above gave way & a fault resulted<sup>33</sup>  
the downthrow of which is about 2000 feet on  
the east. This broke the Pre-Tonto growth  
high on the eastern facing side of the  
fault so that subsequent erosion has laid  
it bare & also the strata above. The down-  
throw being to the east, the drag of the  
strata bent them up against the beds pre-  
viously bent up along the west side of the  
Pre-Tonto fault and the curious structure  
of the Butte fault resulted. Kai-bab





Lectra of north lava Butte.

34

Chinar Valley.

8<sup>a</sup>

The summit has a few boulders of Lento sandstone showing a fragment of the original Lento cap ~~that~~ <sup>sand & edy</sup> rested on the chocolate brown <sup>sand & edy</sup> shales of the Grand Canyon qh. Of these there is 35 feet remaining. They dip N. 5°. Rippled marks & mud cracks occur.

8<sup>j</sup><sub>1</sub>

These bed rests on the surface of a dark gray, fine grained lava which is quite uniform in texture except fillets of sd & qtz in cavities or dikes. The lava has a greenish tinge below & is decomposed into a green ambling debris.

3<sup>3</sup>

3<sup>4</sup>

150 feet.



35

at the base of this bed there appears to be no marked lithologic change.

7<sup>a</sup>

36

a parting between the upper flint bed & the next below is of a dark & chocolate color, evenly bedded & composed of 3 layers forming a band of 6 feet & below there is 2 feet of a shaly character when the summit of the next bed a flint is reached.

Flint no (2)

7

29

29<sup>a</sup>

The summit is a brownish base with numerous (vesicular) cavities which are filled with quartz etc. in the solid unweathered portions. This extends down 50 feet & gives a variety of specimens



24 Lower lam it becomes more solid  
 + the lava compact like that in No 1.  
 200 feet.

6a → a belt of unmetamorphosed reddish brown  
 sandstone conformably overlies the next  
 lava bed beneath which is much like  
 the top bed. Then No 3. 35

→ Compact ~~is~~ was gray colored beds.

240 Breaks into angular fragments on the slopes.

25 This bed is quite uniform throughout except  
 110<sup>a</sup> near the summit where it ~~was filled~~ with little round  
 crystal filled cavities. 150.

24 On the north side of the butte these  
 41 these beds are bent downward & mixed  
 in with a volcanic breccia composed



23 of sandstone & lava & in places sand (37)  
12 appears to be the matrix.

22 Fragments of green carb. copper occur  
23 in association with this mass.

214 In veins running thro' these upper  
fluv quartz crystals occur.

(Difficult to work this section owing to precipices.)

Continued on pg - 48 from base No 4  
from Summit on pg. & pg. 55.

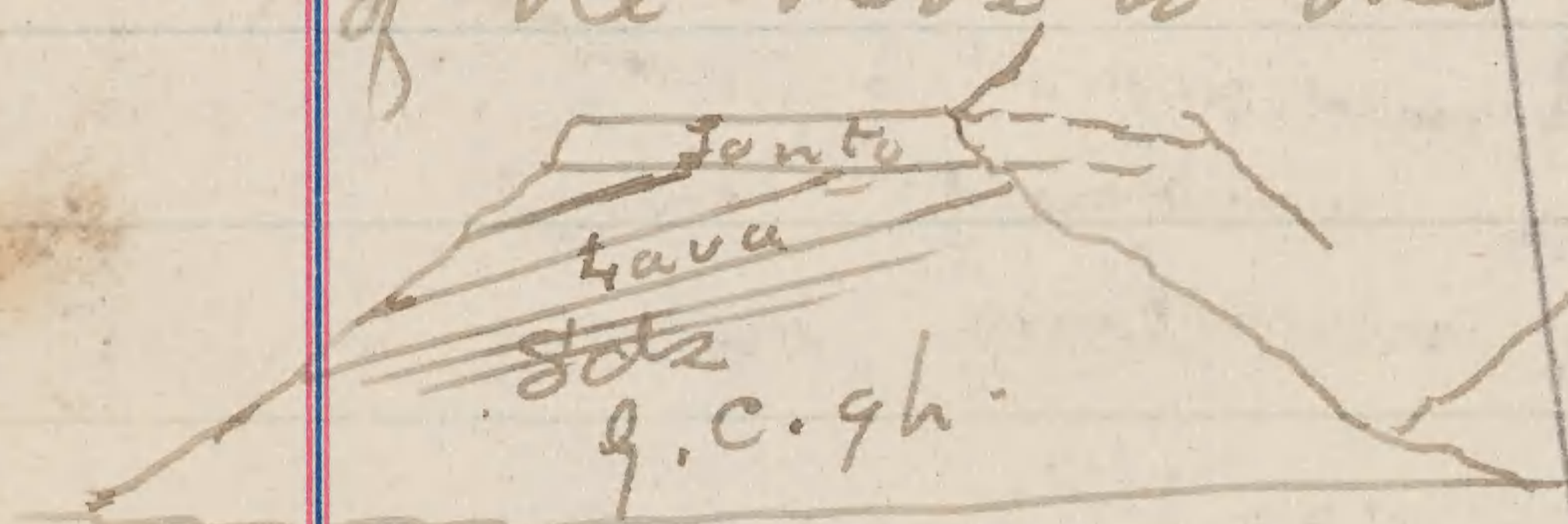


1/8/83.

38

# Pre-Lanto lava flows.

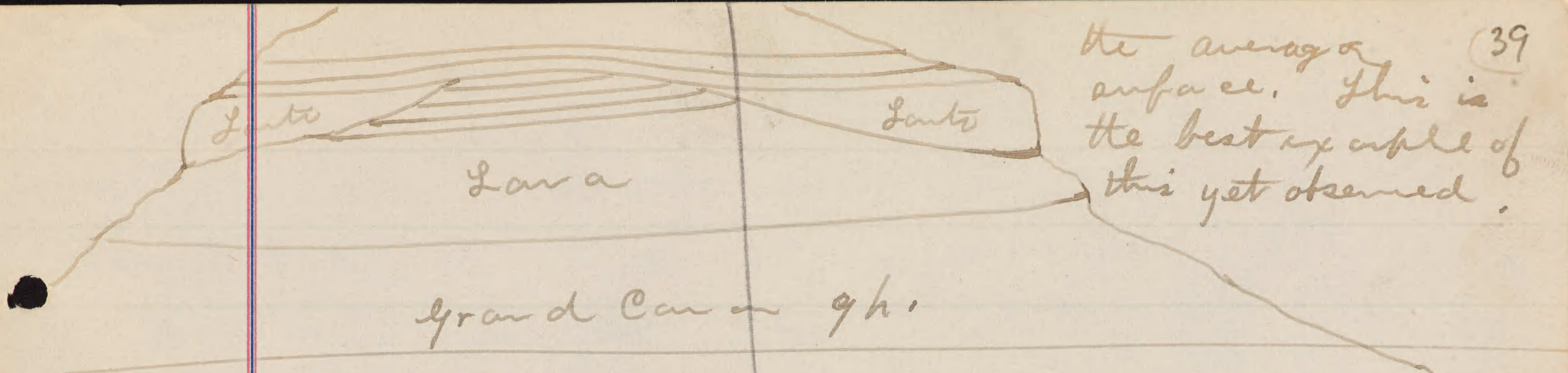
The extension of the lava of the lava butte just mentioned (p. 34-3) crosses the river to the S.E. & is seen under the Lanto cliff. The rise of the beds to the south soon wedges it out



and it is not until the strata of the Grand canyon gh - assume a horizontal position on a broad anticlinal axis that the lava <sup>is seen</sup> ~~appears~~ again. It appears with more or less persistence for two or three miles having a thickness of from 0 to 500 feet.

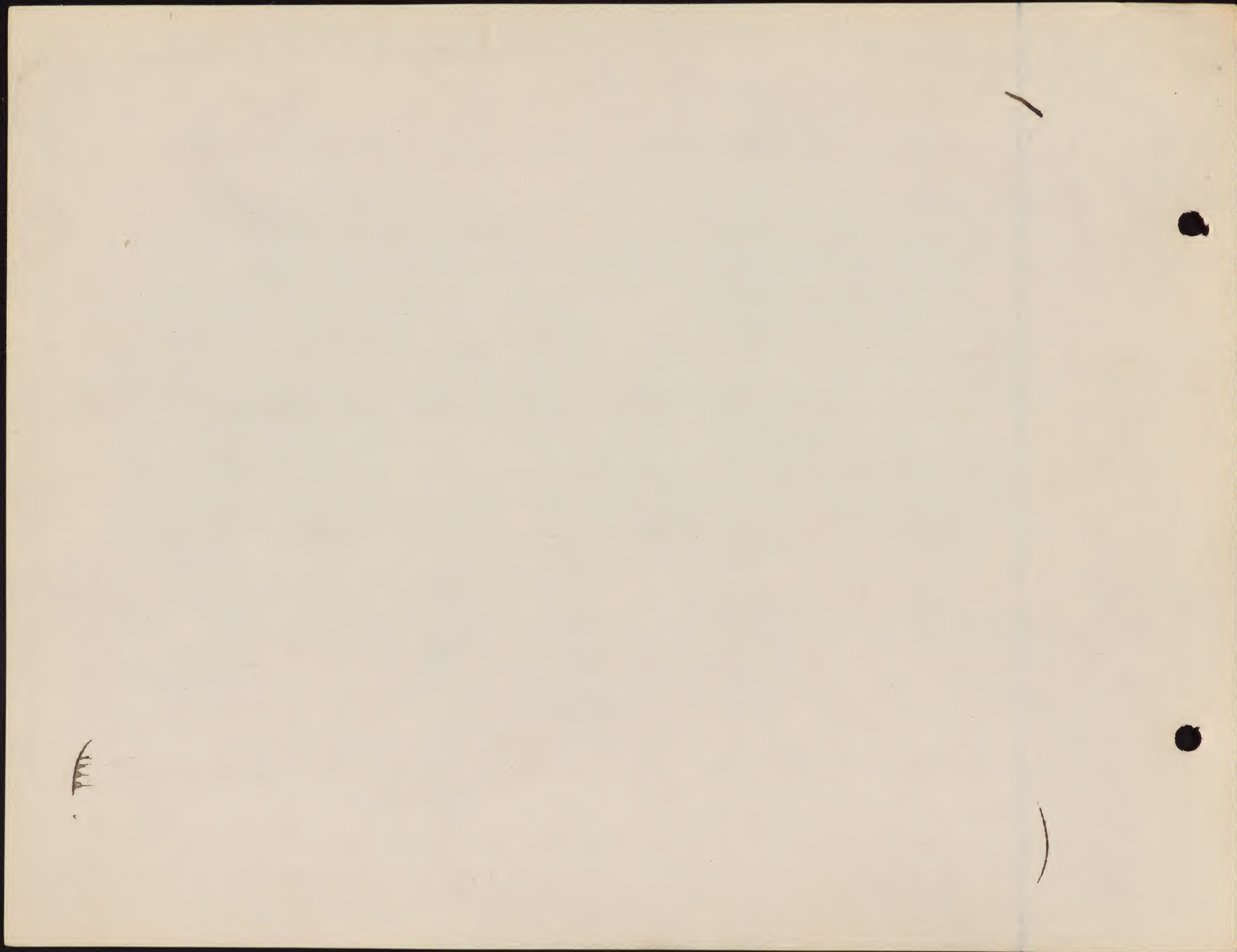
The <sup>Pre</sup>Lanto surface is usual flared off nearly level but at one point an old hill ~~hill~~ remains rising 3 or 400 feet above





On the west side of the river the Larto is higher and the lava flows thicker. On the south side of the south outlet of Chuan valley the rise of the strata cuts out the lava at the base of the Larto but a sharper ~~even~~ anticlinal than on the east side quickly brings it in again with its entire thickness as seen in the lava butte(?) In two instances it appears as tho' canons had existed prior to the flow of the lava & been filled in. (a







Note will be added on China <sup>190</sup> ~~up to the summit~~

Chuan Gp.  
About 2 miles southwest of the mouth of Chuan valley  
a section from the Lanta dam gives 500 feet of  
the variegated clay & arenaceous shales of the  
Chuan gp. above the massive belt of limestone

5) No. 6. of section (letter sheets) Dip 5° N. This  
here 25 feet thick & of a more massive character  
than in Chuan valley. A characteristic  
structure (?) almost Stratopora-like occurs in  
the upper stratum.

Beneath there is about 400 feet of clay &  
sandy shales as in the Chuan section.

(These rest on an irregular reddish brown  
limestone which was subjected to surface erosion  
before the deposition of the shales.)



o) In character this is similar to that in the same 41  
position in Chua valley. Thickness 200 feet.

Below reddish brown sds. evenly & thinly bedded  
extend down 500 feet & rest on the lava  
flow which may be traced continuously to  
the lava butte of Chua valley.

Butte fault

The south  
end of the butte fault line crosses south  
from the west side of the lava butte of Chua  
over a small divide separating the  
Lanto on the point south of the lava butte  
from the main cliff & runs along  
in an irregular line to nearly the  
mouth of the first cañon south of Chua  
valley, where it finally terminates in  
this direction (see sketch north of lava butte)



Along its line south of the lava butte  
 it brings the lava up against the  
 Chuan gk. and has, just where it  
 passed beneath the Lanto on the divide  
 leading from the river south into Chuan  
 valley, a dam <sup>west</sup> throw. (Pre-Lanto) of over  
 1000 feet. & a little south of this it  
 is about 1500 (probably nearly the same on  
 the divide).

On the east side of the river the massive  
 limestone belt is seen just above the lava to  
 the sandstones are much thinner between the  
 l- & sd.



1/9/82.

Grand Cañon gp.

48.  
43

The lithologic character of this group  
are quite uniform in the upper portion:  
the strata consisting of reddish brown and  
greenish sandy shales & layers of a not  
very fine sandstone varying from 2 in. to  
3 feet in thickness. In the more thickly  
bedded portions the resemblance to the  
sandstones of the Trias (Vermilion cliffs)  
is very striking. The shaly portions  
also resemble the shaly beds of the same  
formation. The prevailing color is  
a reddish brown much like that of  
the lower Aubrey sandstone. Round  
greenish spots from 1 mm to 50 mm in diameter



are scattered irregularly thro the  
layers of sandstone & shales. (44)

Traces of organic life are as yet  
unknown. Ripple marks, fine & coarse,  
mud cracks on an extended scale &  
all markings of shallow and water to quite  
shallow exposed frequently to the water & air  
abound. The characters of the group  
thus far corroborates the impression  
by the Chocoma group that a great  
enclosed basin or mediterranean sea  
existed in which the sediments were  
deposited & there existed no connec-  
tion by which the fauna of the older  
Cambrian rocks of the eastern side



of the continent could obtain ingress. (45)  
Only by some such view can I  
account for the absence of a fauna in  
strata that were deposited under  
conditions <sup>most</sup> favorable to the development  
of a rich fauna <sup>marine</sup> flora (faunal). The  
<sup>fauna of the</sup> Lento above shows a connection with  
the later Cambrian of Nevada &  
also the Mississippi valley as shown in  
the Potsdam sandstone.

In going down the river the strata  
of the L. C. group are first seen a little  
distance above the north outlet of Chuan  
valley. They lie conformably beneath the  
Lento cliff & appear to form a continuous



deposit with it. A mile south however <sup>(46)</sup>  
the g. C. beds begin to rise at a rather  
angle to the south and then the S. E.  
branch of the better fault is crossed &  
the Lento is seen capping a cliff  
with the lava flows of the g. C. g. h  
& underlying strata unconformably  
underlying it by a difference of dip  
of  $10^{\circ}$ . The g. C. strata rise at a  
dip of  $5^{\circ}$  to  $10^{\circ}$  for about half a mile  
& then flatten out over a very broad  
synclinal that extends with slight  
undulations a mile or two down the  
shores of the river. In places forming  
cliffs but usually breaking down into



rounded slopes broken by outcropping (4)  
edges of the harder sandstone. As  
in the Chuar group area, the topography  
& geology go hand in hand. The  
latter directing the erosion & the  
topography outlining the geology.



The ... of the ... is ...  
 ... of the ... is ...  
 ... of the ... is ...  
 ... of the ... is ...



The ... of the ... is ...  
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1/14/83

Chuan land butte. (5)

55

Flow No 5 from the base appears to be a true flow altho resting on a thin stratum of sandstone and capped by another.

(33) 18 At the base it is very <sup>tough</sup> solid & compact breaking into angular fragments on exposure.

Color greenish tinged with minute reddish spots particles grouped in an irregular manner.

(34) 19 Fifty feet from the base it is less compact & the reddish & green particles are quite evenly distributed. The former predominating.

(35) 20 Towards the summit the reddish color forms the matrix & cavities of varying size 1<sup>m</sup> to 10<sup>m</sup> are filled with calcite, etc.,



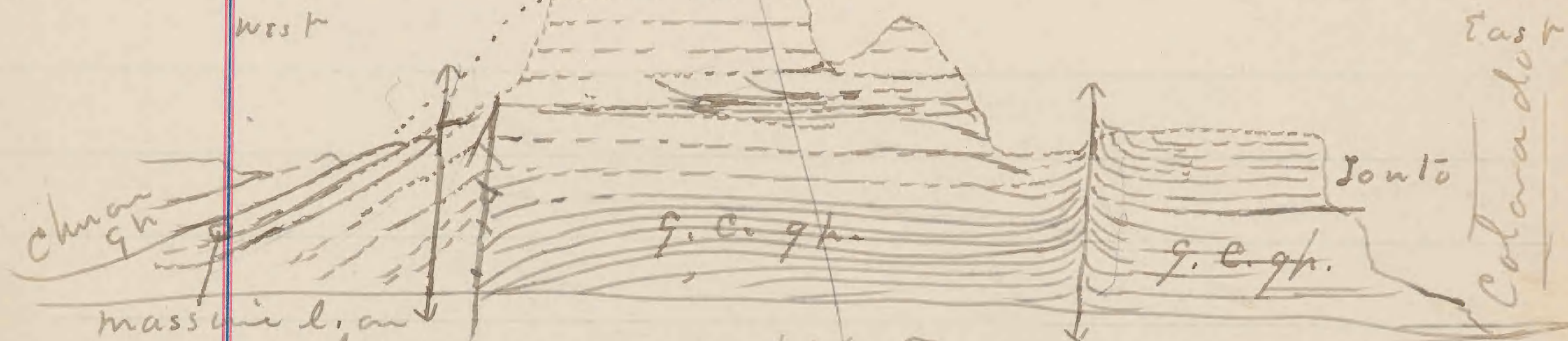
The entire thickness is about 150 feet. Varies somewhat along its line of exposure. In most places presents a small space breaking off a little near the base.

W. 36

Chuar lava hill holds the same relative position to the Lanto base line south & west of it as it did prior to the deposition displacement made by the Butte fault line on its N.E. side. The Butte fault passing to the N.E. and crossing the river while the Pre-Lanto passes <sup>along</sup> <sup>west</sup> to the S.W. base. It also appears that a branch of the Pre-Lanto passed along the S.W. side on the line of the

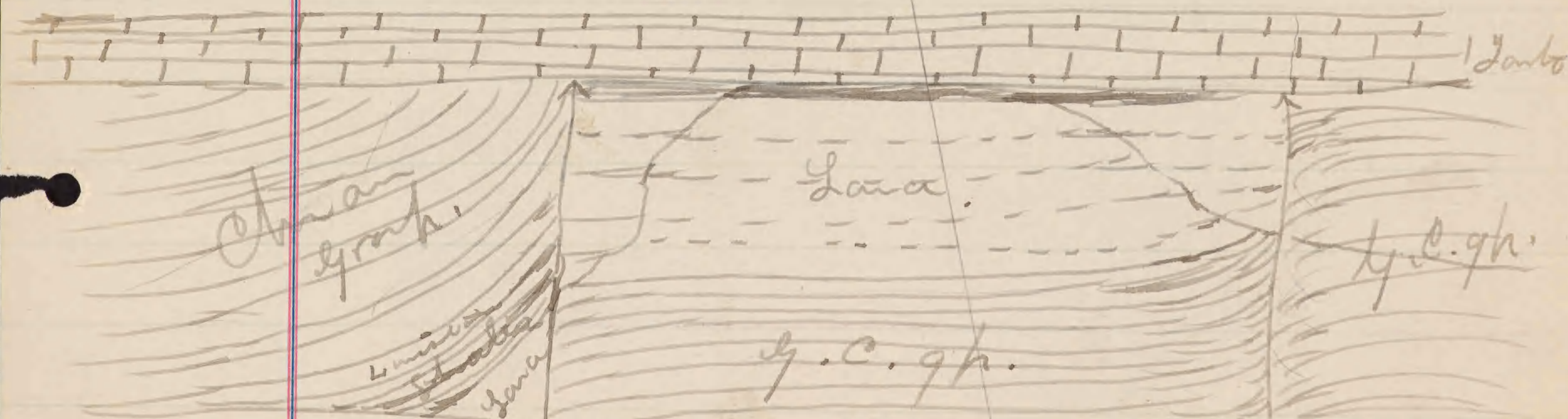


present Butte fault. An east + west<sup>57</sup> section thro' Chuar lava hill shows the character of the Pretanto fault & that the down throw was to the west on each hand.



massive l. on top of lava by 500 feet in undisturbed section

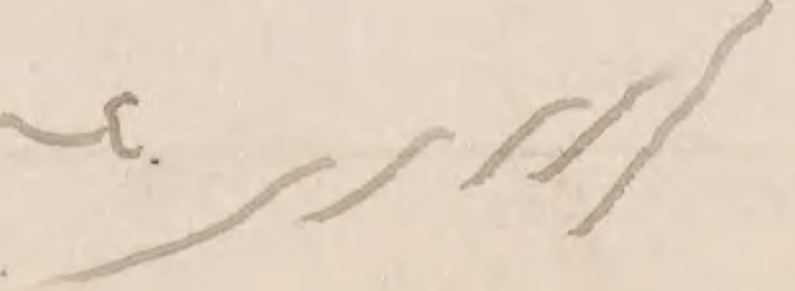
The Tono on the east has been dropped by the Butte fault.



Section before Butte fault & subsequent erosion



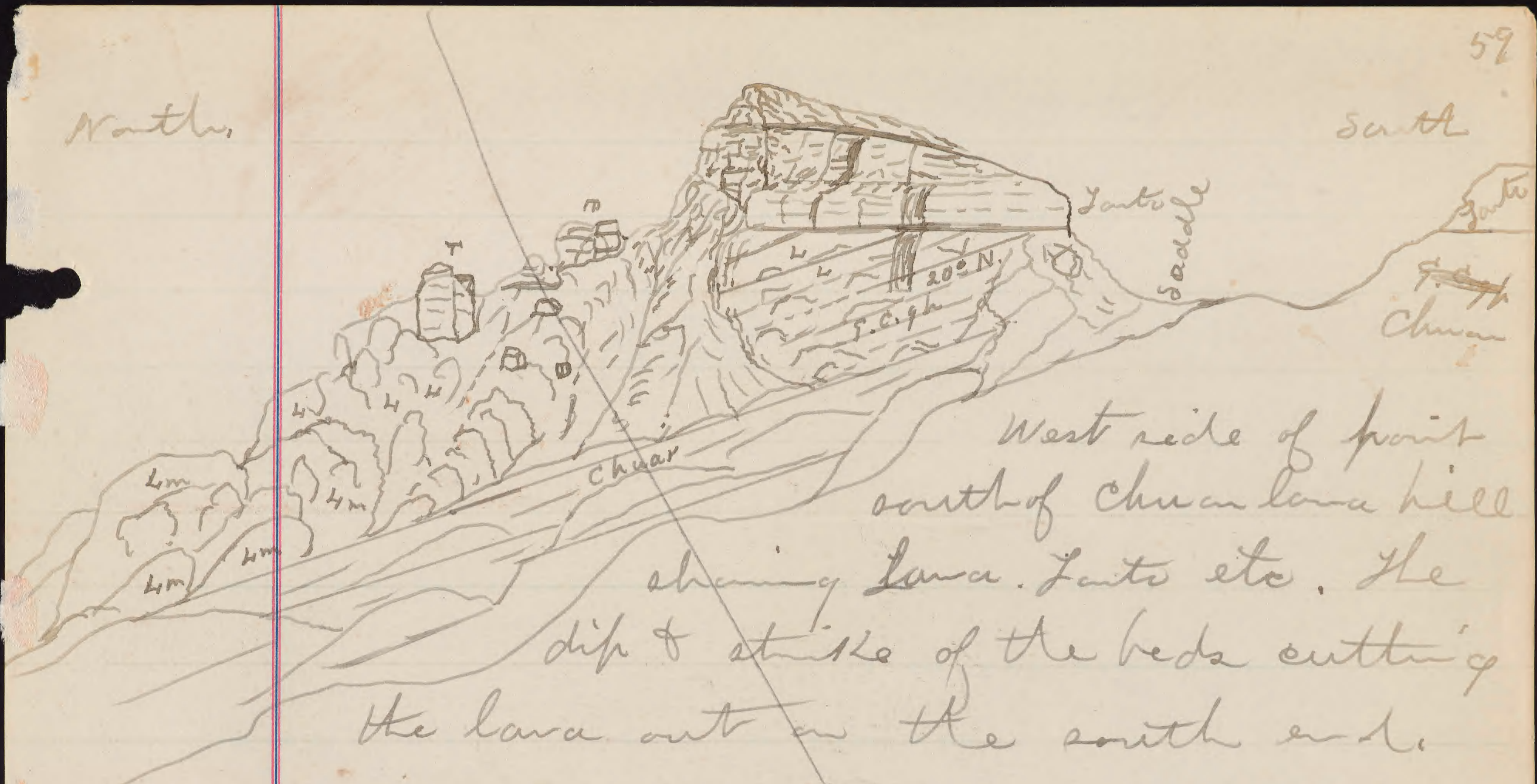
58

The drag of the fault on the west side of the Chuan lava hill has bent the lava beds, underlying sandstones & limestone ~~down~~ & as they have slipped over each other the friction has ~~re~~changed the sd into a quartzite, polished the surface of the lava beds so as to make them appear as tho' they had flamed down the west side of the hill. Several hundred feet of strata between the lava & the Chuan group have slipped entirely out of sight. The same thing occurs on the <sup>west</sup> side of the hill south of Chuan lava hill. The fault line is an oblique dragging one.  slipping & turning the beds up.



North

South



West side of point  
south of Chuan lava hill  
showing lava. Lanto etc. The  
dip & strike of the beds cutting  
the lava out on the south end.



1/15/83,

Profile of ridge on south side  
of Chuan valley.

60

2400 feet above  
camp.

Trail.

2400  
above camp

Red hill

Lento

Saddle.

camp at mouth of canon.

N. Chuan Ridge

Lento

upper Chuan

Canon

Ridge

upper Chuan

Canon

line of section across divide N. of Chuan.

Lento.

Chuan

with 20-25°  
west

Saddle

with 60° E.

South divide of  
Chuan valley.

View on the strike of the strata.



1/15/83

Measured the section of the San Andres <sup>61</sup>  
red sandstone on the butte (Chuar  
opposite the mouth of the little Colorado.

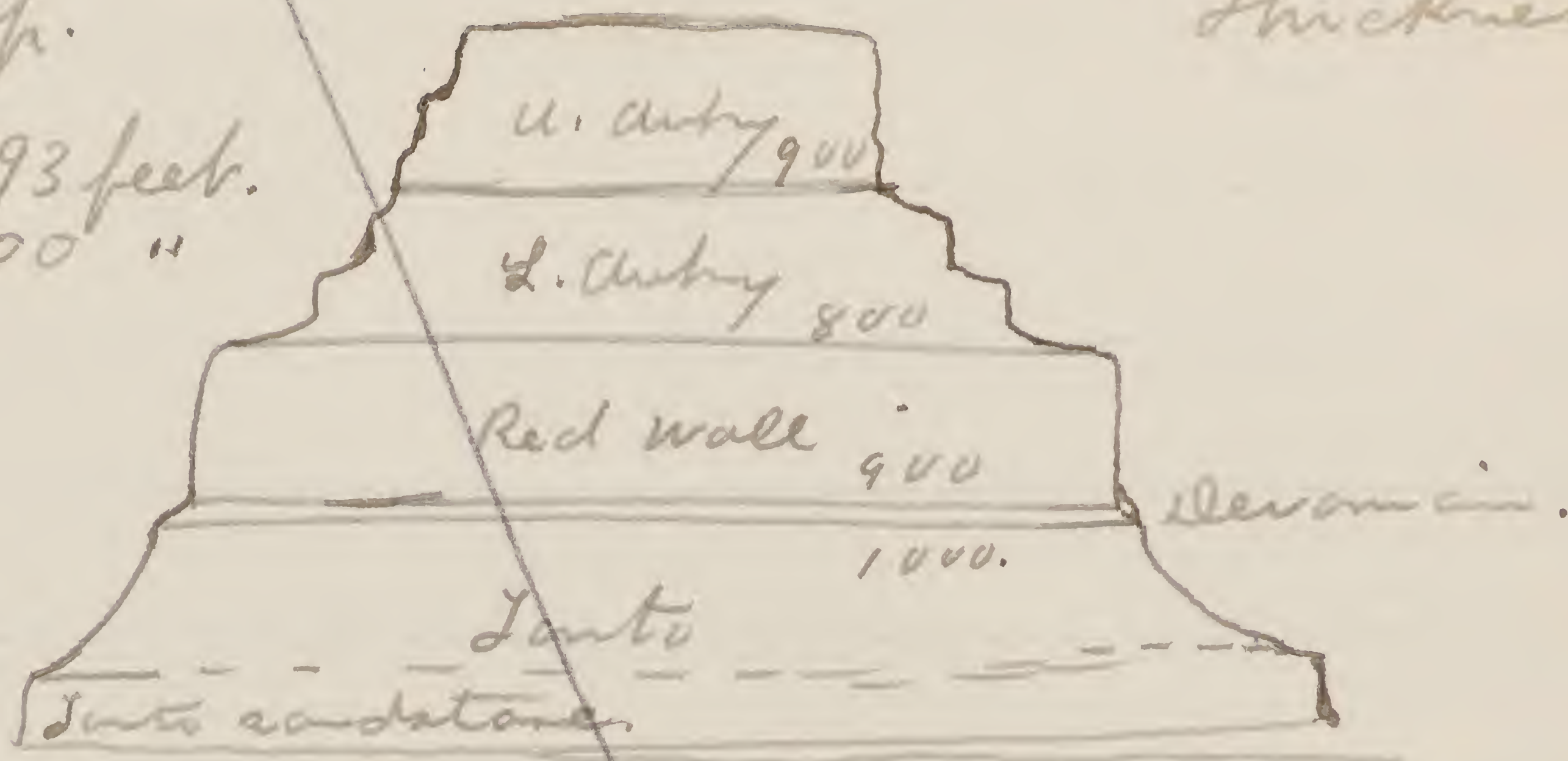
The Red Wall limestone is about the  
same thickness as at Muns-Ho-nech 7  
At the base of the Aubrey there are a few  
layers of a becciated fine conglomerate  
that appears to be made up of bits of the  
(a) red quartzite, pebbles, etc.,

~~which is a limestone~~ is an arenaceous  
matrix. The lower 250 feet of sandstone  
has broken up leaving a terrace on the  
summit of the Red Wall l. Several massive  
crossbedded layers form a ledge and above  
another terrace occurs at the foot of a similar  
ledge which is capped by a terrace slope



that extends to the foot of the massive <sup>62</sup>  
crossbedded gray sandstone of the Upper  
Anby group. thickness.

Locks level 793 feet.  
Barometer 800 "



The Upper Anby is inaccessible but a care-  
ful measurement in comparison with the  
Red Wall. Taken  $\frac{3}{4}$  of a mile distant & at  
the level of the summit of the Lower Anby  
gives 900 feet for the upper on the east  
side of the <sup>Colorado</sup> River just below the mouth of  
the little Colorado.

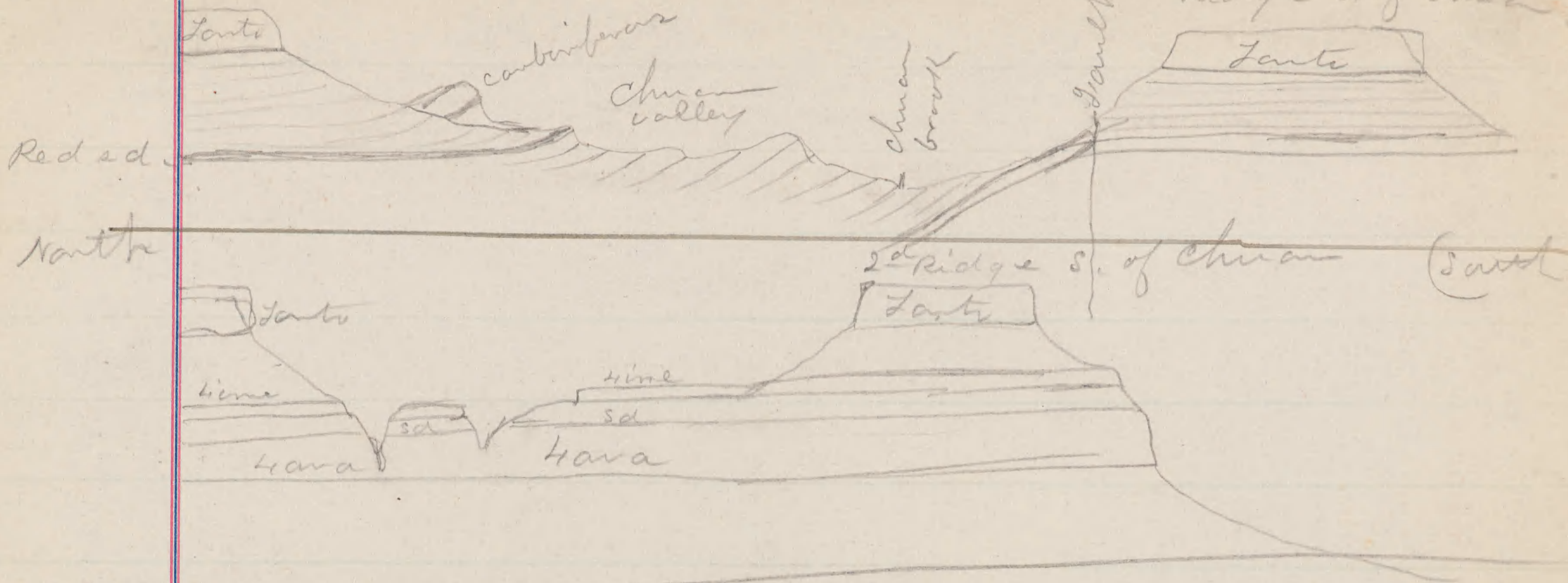
13001



1/17/83.

Line of Section

63



Windy cold day. Camp on ridge S. of Chuan valley  
2200 feet above the river.

The Devonian 1 mi. south of the locality  
previously mentioned as on the south side  
of Chuan valley is well represented & a  
slight but distinct nonconformity exists  
between it & the base of the Red wall



64

limestone. In some places a brecciated  
limestone conglomerate in a matrix of  
greenish clay shale occurs. The layers are  
massive & a curious conglom'g of limestone  
calcareous sandrock & sandstone. All these  
occurring in a layer passing from  
sandstone to limestone. There is no  
conformity at its base altho' the  
line is well defined. An Athyris-like  
shell & a Murchisonia were found in the  
limestone & scales of Placogonoid fishes  
in the sandstone.

Total thickness of Devonian. 125 feet.



1/18/83.

~~Moved to lower end of canyon E. of Victoria Heights.~~

65

1/17/83.

rough day  
snow (A)

Section of Grand Canyon from where it is marked (granite) crystalline Archean rocks. A belt of quartzitic sandstone of 20 feet in thickness rests on 75 feet of hard fine sand & this forms the ledge through which the Colorado canyons before reaching the Archean. This belt is the cap of great series of fine bedded dark reddish brown sandstones that rise from the river at a dip of  $10^{\circ}$ . It forms a precipitous cliff. When the quartzitic cap is 1700 feet above the river lighter colored reddish brown or buffish sandstones appear that are similar to those above near the summit.



75  
372  
425

500.



of the group. The 1700 feet of sandstone<sup>66</sup>  
was not measured in detail. Only by the  
height of the cliff above the river where  
the shaly red beds came from beneath.

Going up.

On the quartzitic belt capping the firm  
strata a series of irregular bedded  
sandstones come in. For 125 feet they are  
a friable, shaly in places, <sup>light</sup> gray with  
reddish spots. Greenish sandy partings.  
A massive layer of 10 feet forms a little  
ledge & then a curiously gnarled & twisted layer  
of 15 feet that is overlain by 300 feet of  
& friable sandstone & sandy & micaceous  
shales of a greenish tinge. 125 feet of



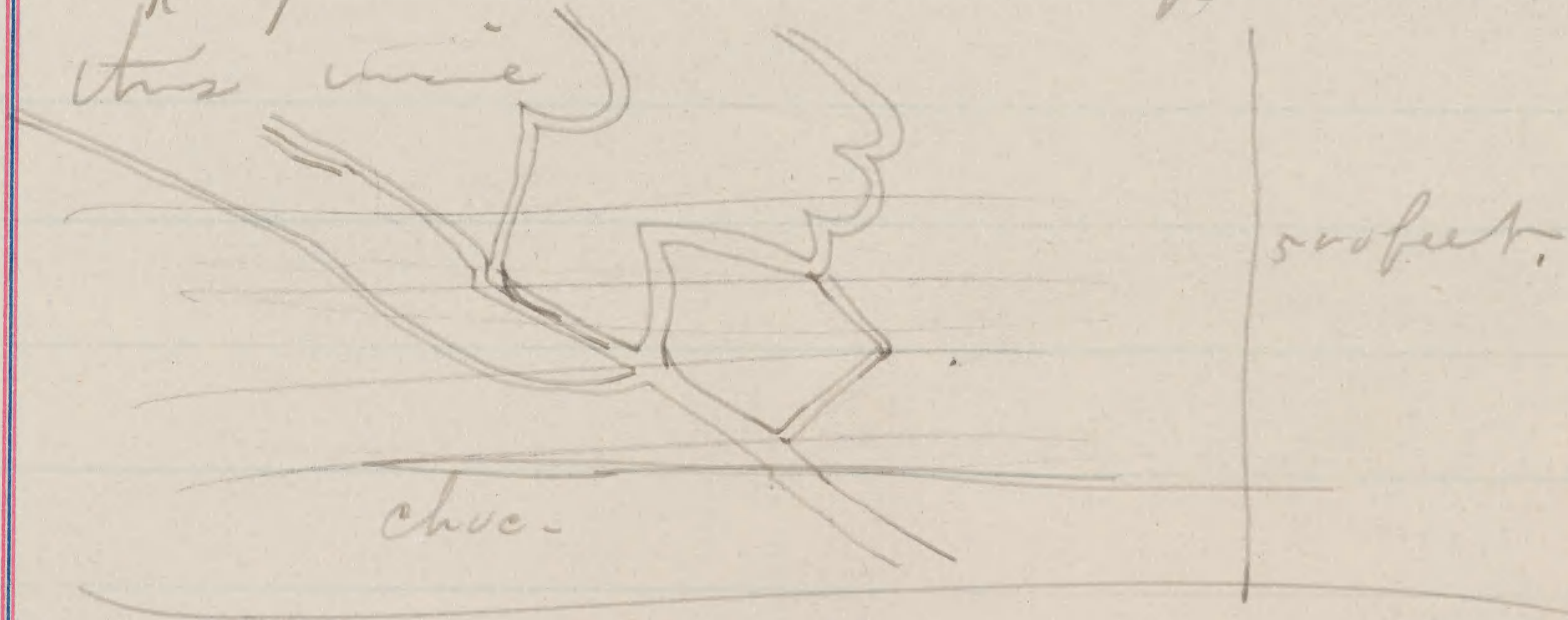
greenish chocolate more or less stratified  
sandstone & the base of a firm  
chocolate colored sandstone is reached.

Total thickness of this stratum 575 ft.  
Locks level.

a The next superior series of sandstones form  
a cliff broken into by 5 massive bands  
by partings of a greenish sandy shale  
below & chocolate colored above. The  
chocolate colored <sup>also</sup> deepens towards the  
top. The sandstone is fine grained  
micaceous, breaking into shaly layers on  
exposure. The last 125 feet is more friable &  
breaks down joining the slope of the  
venue in sandstone above into which  
it merges in color.  
(Locks level) Total thickness 925 feet



§§/ In one of the east canyons leading down 68.  
from Vishnu's Temple a section of the lower  
portion of the Vermilion colored upper  
Grand Canyon gp sands is exposed & the  
summit of the ~~same~~ chocolate beds below.  
A <sup>large</sup> dyke has broken up this & runs in  
(this mine)



Could not cross to obtain specimens



1/20/83

clear &  
cold  
freezing  
pen frozen sh.

Continuation of section pg. 67.

236

69

The chocolate beds grade into the Vermilion colored beds still there is a fairly drawn line between them. In 700 feet the Vermilion beds retain a uniform character massive strata with shaly partings, the massive beds breaking up into shale on the slopes. Above 700 feet a greenish gray layer of sand beds ~~beaten~~ alternating with the Vermilion beds and breaking the otherwise uniform color of the series. Ripple marks & mud cracks mark the upper beds and their shaly character causes them to break down readily & form rounded slopes except where protected in narrow



960.2  
480.2  
480.2  
542.1



canons by the overlying lava beds.  
(See previous note on these beds below  
Chuan article) Locks level (1732 ft)

1730 ft

Location continued.

1/21/83.  
Cold.  
Notes taken  
in pencil &  
copied.

The upper beds of sandstone are  
evenly bedded & unmetamorphosed.  
Retaining their usual color & hardness  
of the strata beneath.

(1) The first stratum of igneous origin  
is similar to that of Chuan lava hill  
& may be traced with two slight  
interruptions to it.

On weathered surfaces it presents a  
slope of 25° to 30° crumbles into a  
light olive green, coarse sand. Thin

at



306

1530

200

1700



beds of sandstone similar to that below  
occur in several places & one at 125 feet  
from the base is quite persistent. The  
upper surface is slightly undulating &  
nodular. 250 feet

<sup>2</sup> Reddish brown sandstone hardened  
at summit 15 ft.

<sup>3</sup> Solid, compact stratum of a dark  
& reddish ~~travertine~~ <sup>greenish</sup> with a tendency  
of the middle portion to a column-  
ar structure. The entire stratum  
apparently formed of three successive  
flows as two division lines occur



1/10/83

48

# Chuar lava butte.

All along the south base the redish brown sandy shales & sandstones of the G.C. gp., reach up from the canon bed ~~0 to~~ 50 to 250 feet their upper line of outcrop forming a curve one end resting at the west <sup>or upper</sup> end of the canon & the other at the east end near the shore of the Colorado river. The general dip is a little east of north,  $5^{\circ}$  to  $10^{\circ}$ . The upper surface of the sandstone is quite ~~uniform~~ not having been eroded irregularly from the lava flows. It presents ~~but slight~~ traces of metamorphism <sup>as shown</sup> in the tendency to break into angular fragments & a slight hardening as compared with the sandstone below. ~~§~~ The lava appears to have been



greenish

deposited in some other way than a fluid (47)  
matter mass & is more like a volcanic sd.,  
or lava deposited <sup>under</sup> water.  
~~And~~ the ~~evident~~ lines of bedding in the  
lower portion not parallel to the sandstone  
supporting this view.

spec. Reddish  
spec. greenish  
like 2.

When it rests directly on the sandstone the  
rock is more or less porous, small cavities occurring

that ~~some~~ <sup>above</sup> are ~~filled~~ <sup>lined</sup> with ~~quartz~~ ~~is~~.

above the mass becomes more compact than  
" 14 a <sup>at</sup> reddish tinge & the cavities have a green  
lining including calcite? (2 feet)

Brownish  
greenish

This passes into a <sup>less</sup> compact rock that  
weathers into a coarse greenish colored

dark  
green

sand. 2 1/3 Bunches <sup>or nodules</sup> of a hard ~~lead~~, more  
compact rock occur in it (Probably the original  
condition of the entire mass.



Redish  
22

50  
This greenish color + general character continues  
on up <sup>towards</sup> the summit of the stratum on which where  
the more uniformly granular structure is  
replaced by larger irregularly spheroidal  
concretions 1<sup>st</sup> to 20 mm in diameter filled with quartz  
calcite etc.

60 feet from the base a stratum  
of redish brown sandy shale 10 feet thick occurs.  
This + the fact that traces of bedding are present  
up thro' to the top adds to the view of the  
subaqueous deposition of the stratum. (15) 100  
feet from the base a belt of sandstone +  
sandy shale 12 to 25 feet rests on the coarser  
upper <sup>part of the</sup> stratum.

The bed just described with its capping  
of sandstone is a marked feature in all



(51)  
the exposures of the volcanic rocks along  
down the cañon for miles. Descending  
readily it forms a sloping terrace that is  
marked by its smoothness & bottle green  
color. Its stratigraphical position is also  
strongly defined. 1/11/83. (No. 2)

423 The lower portions of the sandy belt  
do not show metamorphism but at & towards  
the summit it is changed to a hard almost  
quartzitic rock & weathers like a quartzite  
breaking into angular fragments.

924 The floor above this has a stratum of sand &  
& lava (?) of irregular thickness followed by a  
massive bed of fine dark green to a steel  
gray greenish-tinted lava. It breaks into

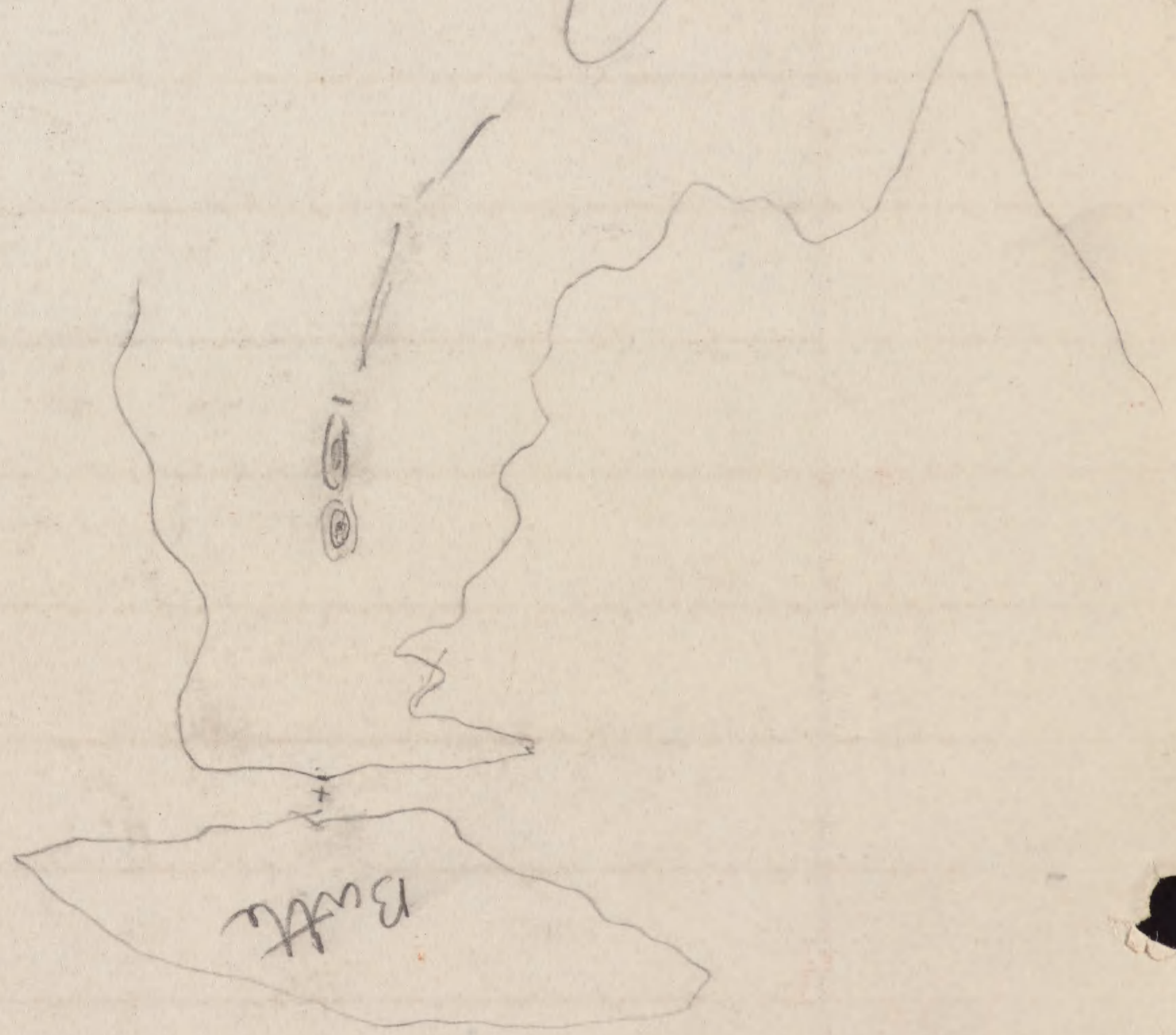
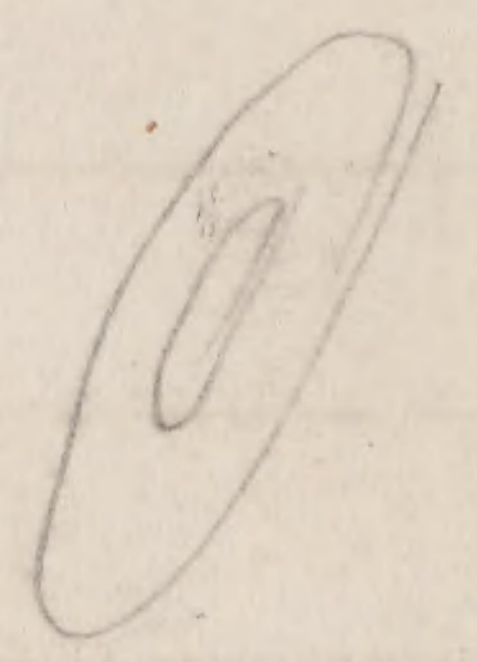
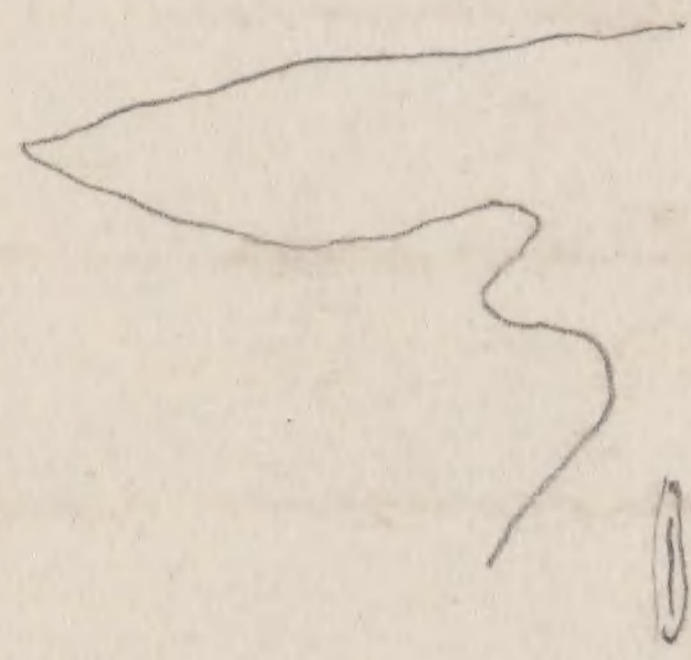
1925



angular fragments + high up in the flow has become  
26) a slaty structure. Near the summit its  
macroscopic character changes + little cavities  
12) filled in with calcite, quartz etc. occur. When  
the section crosses the thickness is 100 feet (at the  
east end of the cliff. At the west end  $\frac{1}{2}$  mile  
away it is nearly 200 feet. (No 3.)

The line of demarcation between the last  
mentioned bed + the upper stratum is  
<sup>i.e. change of color etc.</sup>  
13) ~~poor~~ lithologic, but still clearly defined by the  
erosion leaving a creviced line all along  
the face of the cliff. The bed above this line  
is to all appearances a massive lava but  
when broken looks like a sandstone of a  
reddish brown color. Higher up it changes







14

somewhat and being filled with  
minute yellow spots & thin seams. 75  
feet from the base it passes into a reddish  
brown mass with enclosed particles of  
a green color. Thickness 100 feet.

15  
30

No. 4.

16  
31

The floor above is more uniform in  
character. A reddish brown rock not  
unlike 30 in appearance with larger  
cavities filled with quartz etc,  
Thickness 125 feet.

17  
32

This is overlaid by a belt of reddish  
brown fine grained sandstone 5 to 15  
feet thick



but without sandstone.

72

25 ft. 125 ft. 25 feet.

175 ft.

4 Ten feet of a vesicular lava capped  
by a thin stratum of sandstone 10"

38 5 In appearance much like that  
of 3. (preceding page). Capped by a  
stratum of sandstone 2 feet thick 70"

6.

Similar to 5 in lower half but  
does not cliff above & the talus  
slope is of a lighter green color 100"  
Capped by sandstone. 1 foot.

7. In appearance like 3 75  
& capped by 5 to 10 feet of sandstone



11/7



8. Breaks into small angular fragments &  
more of a reddish tinge than the beds  
beneath. Upper surface a little  
irregular.

Total

100.  
795.

To the north the lava  
series thickens somewhat as at  
Chuan lava hill it is over 1000 feet.

The last lava bed is overlaid by  
reddish brown, ripple marked & mud  
cracked, fine grained sandstone & shales  
like those below the lava beds. The  
section shows the action of the  
sea between the flows & that



the first was probably ejected (79).  
into the water & spread by the  
waves or currents. The other beds  
appear as tho the lava had spread  
evenly on a land surface & then  
been covered by a thin deposit  
of sand before the next eruption.

Several lava dykes occur not  
far away from the lava cliff  
but none could be traced directly  
to it. The lava in them appears  
to be similar to that of the second  
stratum. (2).

39  
H 0 a  
H 1  
H 2



Section continued.

75.

1 Reddish brown sandy shales & sand-  
stones. Rippled marked (2.4.198) 200.

2 Partially crossbedded fine grained  
purplish brown sandstone 50

3 Massive irregular beds of a yellowish  
brown sandstone (2.4.300) 50

4 Shaly light gray sandstone 25

5 Calcareous sandstone passing into a  
vesicular irregular limestone.  
a Gray, reddish color etc

50-150  
375 475



This last stratum of limestone class  
 the Grand Cañon gp. as on it rests the  
 shales etc., of the Chuar gp. Its upper  
 surface here as in Chua valley is  
 irregular & nodular & a different  
 source of sediment is shown by the  
 Chuar beds. With the exception  
 of the lava dykes the lava outcrops  
 does not appear to have been ac-  
 companied by disturbance of the  
 strata or any orographical movement,  
 the same character of sediment  
 follows that precedes it.



~~§ §~~ Unkan

Unkan Valley

77

~~Unkan~~, valley is the <sup>most southern</sup> last of the inner valleys of the Colorado Grand Cañon. At its southern side end the inner cañon narrows & does not again widen out until its mouth is reached. Unlike Nav. Ko-mech & Kwa-gunt & Chino valleys it opens directly on the river & the river flows thru' it in its central portion (the Lanto cliff outthrusting the valley). It is almost entirely eroded in the vermilion colored sds of the G. C. gp. below the Lanto cliff the strata dipping at low angle to the northward. The friable sandstones & shales weather into rounded slopes ridges & hills & the topography is much like that of inner



Chuan valley. except that on the north the lava cliffs take the place of the massive red soil of the latter. One spring ~~exits~~ flows for a half mile in the main cañon.

Above it on the south <sup>W</sup> rises Vishnu's Temple and on the S.E. S.W & west the beautifully eroded cliffs of the outer cañon walls.

SS. Lava beds.

The rise of the strata to the south carries the lava beds up against the Pre-Linto surface line & altho' resisting so as to leave a hill or ridge along these <sup>lines of</sup> strike of the they are cut off midway of the valley & do not appear again to the south. The dykes that formed them only showing them further back a few miles further south.



Grand

Hana

100

Grand Canyon gk. acts,

4000

4000

600

1000

fallen and the head

1000

1000

1000

Antennae of larva exposed  
on east side Grand Canyon.



of ...

10"

5. In appearance much like that of 3.  
except with a band of sandstone 2 feet.

70"

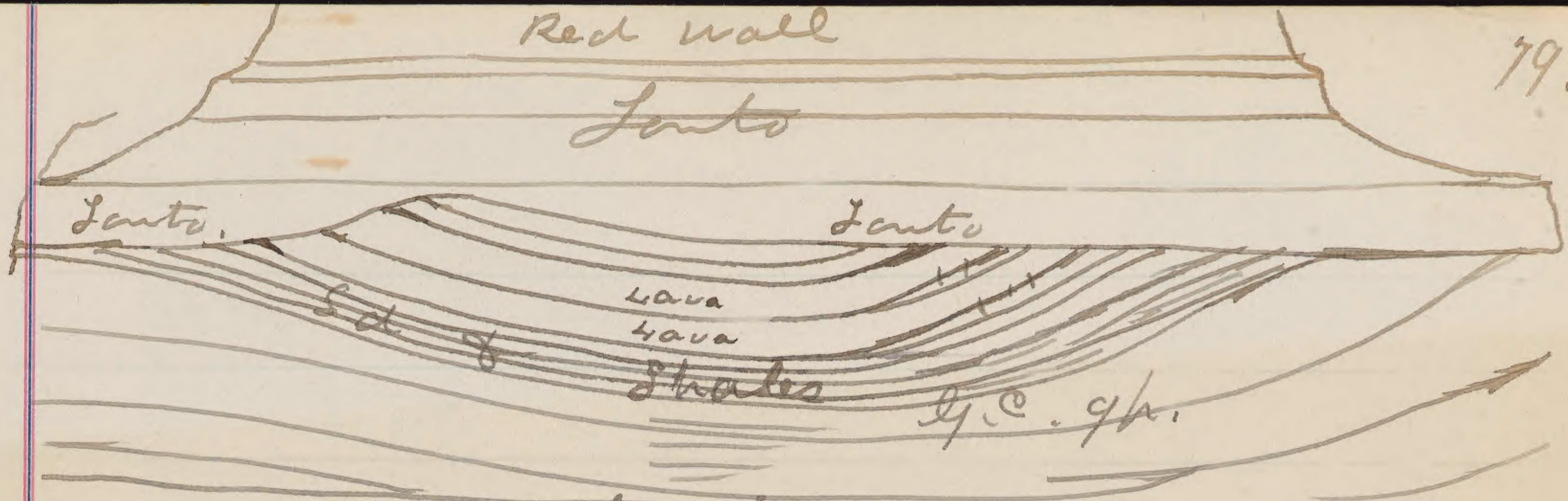
630

6. Does not differ much from the other half as much as  
that below. ...

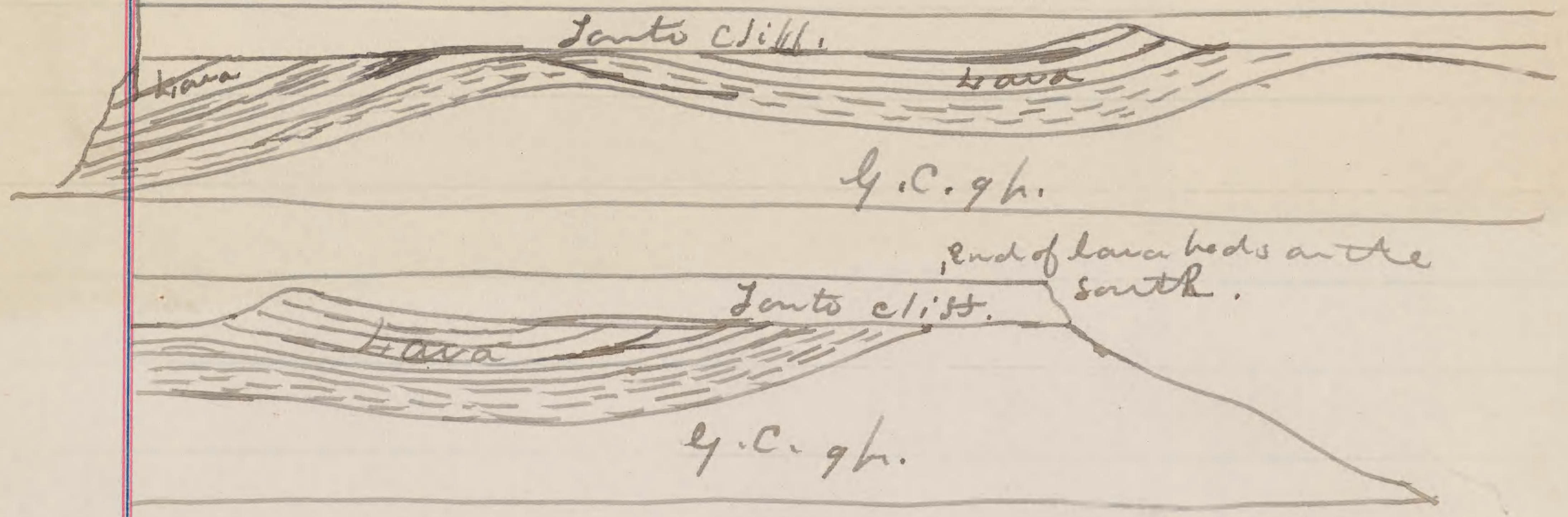
100"

7. Like 5.





East sided of Grand Canyon showing lava beds in synclinal in sandstones of Grand Canyon gh. fault opposite Chuar outlet





1/22/83. S<sup>S</sup> Followed the cliff of the Lanto sandstone (80)  
around to the S.S.E. of Vishnu's Temple. At  
the great bend in the ruin & cañon  
from the S.S.W. course to W.N.W. The  
Archean rocks appear from beneath the  
evenly bedded vermilion colored sandstones  
of the Grand Cañon group. The latter  
dipping at <sup>an</sup> angle of 10° to the N. 40° E.  
Between the latter & the Archean a  
stratum of lava (Greenstone) occurs.  
Estimate of shaly sandstones beneath  
massive beds mentioned the 19" 600 to 700 ft.

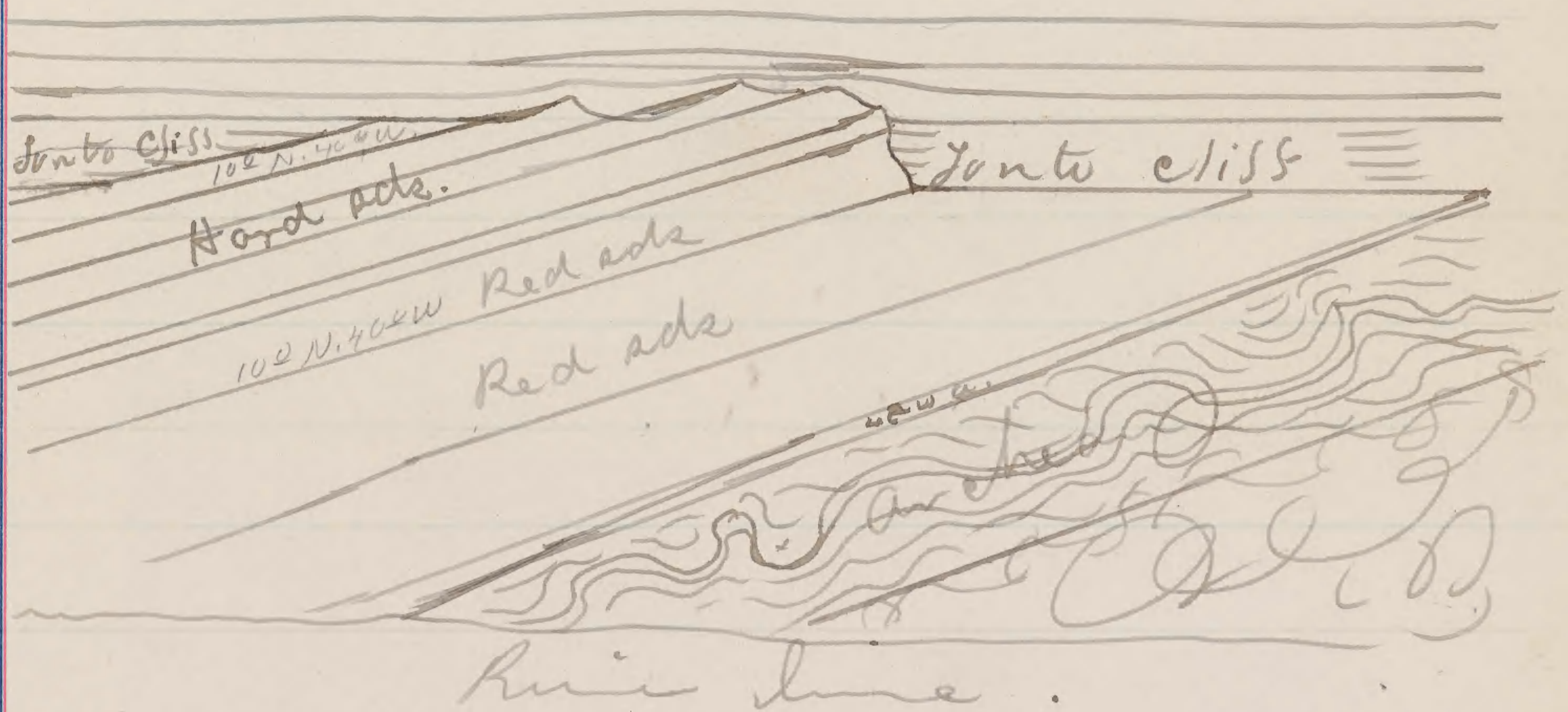
S.S.

Pre-Lanto surface.

The belt of quartzitic sandstone with  
the finer sandstone beneath is prob.



up to the Lanto base line by the upward 8,  
 southern dip it forms a ridge cutting  
 up into the Lanto as high as 500 feet.  
 Thro' the massive sandstone cliff &  
 into the softer sandstones above.



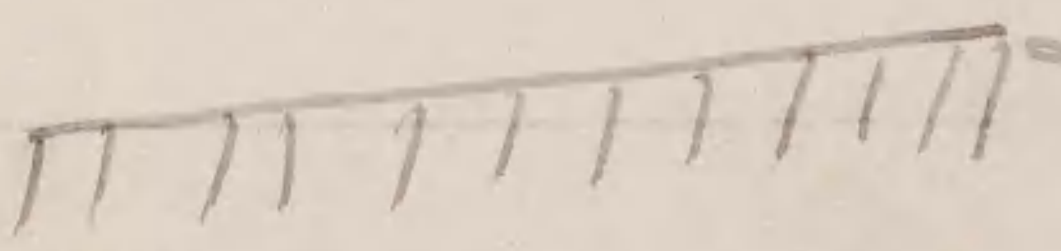
On the north side of the river obtained  
 a specimen of the quartzitic sandstone



just under the Lanta & showing the  
 surface polish of the waters that were  
 among the Pre-Lanta land surface.

1/23/83 ~~Played out. A day of rest.~~

1/24/83 <sup>SS</sup> Summit of the Archean rocks in the Grand  
 Cañon due south of Vishnu's Temple.

The Archean at this point consists of  
 metamorphosed sedimentary rocks & gneiss  
 (a) mica schists, quartzite, reddish granite in veins  
 etc. Where the section strikes the Archean  
 the surface of the latter dips N.  $50^{\circ}$  E. <sup>10.0</sup> St N.  
 $40^{\circ}$  W. (True strike & dip). The strata are vertical  
 to the horizon  & mostly thin  
 layers of quartzitic sandstone with layers



- 1 of micaceous schist & a reddish granite
- 2 rock. The slope of 100 carries this surface rapidly from the river to the base of the Tonto as the cause of the canon is nearly E & W. and there the surface is planed off nearly horizontally minor irregularities alone remaining. The Grand canyon gh is entirely wedged out between the Tonto base line & the Archean line.

and does not appear again as far down the canon as the mouth of the South west canon leading down from Vishnu's Temple (I doubt if all again in the canon.)



Section

1) On the Archean surface (Pre-4. C. 9h. surface) §4.  
a band of siliceous conglomerate rests  
evidently formed of material worn from the  
Archean as pebbles of a character similar  
to the underlying rock abound in it. The  
conglomerate is firm but breaks  
down on exposure to the weather.  
30 feet.

2)  
Light gray compact shaly limestone with  
pinkish tinge along the laminae of bedding.  
A little cherty at base on thin <sup>hard</sup> sandstone  
layer intercalated  
26 feet

3.  
Dark green lava (Greenstone) in massive  
stratum. No change in limestone where it



rests in contact with it. (See note pg. 86). 85

80 ft.

4. Limestone similar to 2.

14 "

5 Dark redish brown slate

5 "

6 Redish brown sandstone

2 "

7 Cherty redish limestone

10 "

8 Brown sandstone with a bed of  
siliceous conglomerate 2 feet.

30 "

9 Limestone with interbedded thin  
laminae of quartzitic shale

8 "

10. Redish brown siliceous con-  
glomerate 10 feet followed by shaly  
brown sds in somewhat massive  
layers

80

11 Brown friable shaly sandstone  
Ripples and cracks

300



11<sup>a</sup> Brick red  
yellowish red friable shaly sandstone 86.

11<sup>b</sup> Reddish brown to venice in friable  
shaly sandstone 250.  
200  
750.

The strata of 11. form a sloping  
terrace in thin shaly line of exposure  
just along the cañon south of Vishnu's  
Temple. (about 1 mile).

12.  
Massive compact, cliff forming brown. buff  
& purplish brown sandstone. 1200 ft.

Capped by quartzitic band.

---

Note on No 3. The limestone is a smooth &  
soft at the point of contact or below.  
The lava bed is constant on the north



side of the cañon from the ruin to where 87  
cut out by the Pre-Lanto erosion but on the  
south side it rises from the ruin & ~~is~~  
suddenly disappears as tho' the termination  
of the bed. It is not faulted out but  
~~simply ends.~~ simply ends.

Several dykes of greenstone were seen  
cutting up thro' 11 & 12, but none meas-  
urable. 12 was estimated by knowing  
the height from the ruin to the  
base of the Lanto & 11, measured by  
the aneroid barometer.



1/25/83

~~Vermilion~~ <sup>Wink</sup> valley. = Un + Kar (88)  
give Pah-Ute name for Red. Pasa-90-?

The view from the southeastern side is one of the most beautiful & impressive of any of any of the grandeur of scenic & geologic interest in the valley portion of the Grand Cañon.

An immense amphitheatre enclosed on all sides but the north by these high, precipitous outer cañon walls & on the north massive buttes rise 3000 feet to ~~stare~~ then ~~rather~~ dropping suddenly 1400 feet to the level Santa terrace that holds a level line until breaking in pretty pointed



knolls it is merged into the sweep (89)  
of the Plateau margin on way to  
the northeast. Within these outer  
walls ~~(rise from)~~ the Linto terrace  
winds in & out, here a bold headland  
there notched by a narrow profound  
cañon; a symmetrically curved point  
around which the contours sweep in  
graceful curves ~~to~~ only <sup>to</sup> recede around  
a broad open cañon and on to a point  
that is as sharp & clearly defined as  
the leaves of <sup>its characteristic plant</sup> the ~~plant~~ that almost  
appears to be coextensive with the  
terrace. From this terrace line a  
gently curved slope broken here & there



by the darker line of outcropping strata that (90.  
whose outline is that of the terrace contour, rises  
to the base of the beautifully sculptured &  
varied points, buttes, headlands, mural walls  
precipices within the dark forest clad outline  
of the Plateaus.

Beneath the Lolo terrace another world is  
entered. The Lolo cliff of 300 feet gives way  
to slopes in the <sup>red</sup> basin-like valley through  
which the Colorado meanders like a stream  
of ~~smaller~~ <sup>smaller</sup> size in some New England valley,  
less pretentious valley. To the north,  
however, the river enters thro' the dark  
green lava cliffs & on the south passes  
out thro' a narrow canon worn deep



in the dark chocolate<sup>colored</sup> sand stones.

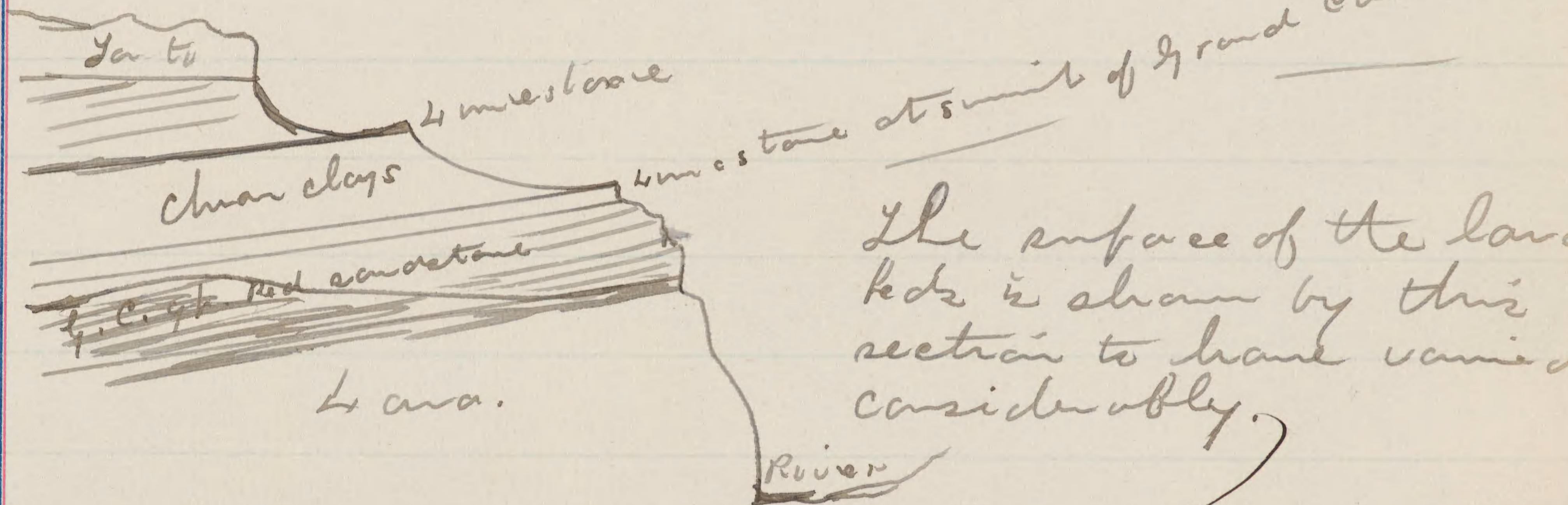
(91)

The coloring is more in mass than that of Chuan valley. The rich redish brown of the ~~surrounding~~ <sup>rising</sup> slopes & low cliffs of the inner slopes is toned by the gray bands before reaching the high slopes of dark olive green on the lava beds to the north which give a strong but pleasing contrast to the buff tints of the Lata cliff with its slope of subdued green above. To the south the dark chocolate <sup>tints</sup> ~~sandstones~~ replace the green of the lava & here & there a dark green line shows the course of some lava dyke that fed an outflow of Pre-



Chuan date, but last in the series of (92.)  
Pre-Lanto times.

Section from Lanto to river.



Caused by an E + W fault bringing  
up a mass of lava against the cliff.



1/27/83.

Southeast branch of the Butte fault on south (93) side of Chuan-lana hill.



Ruin line.  
Fault with throw to the north of about 400 feet.

as seen on the east side of the ruin, showing the Kaibab fold taking it up at the Red wall limestone the down throw at the Lanto base line about 400 feet. at Chuan-lana hill this increases



to 800 or 1000 feet. On the line of the fault  $\frac{9}{4}$ .  
on the east side of Charlara hill. The sand-  
stones have been changed to a quartzite  
& turned up on edge from beneath the lava.  
In some places forming a becciated conglomer-  
erate that is impregnated with green carbon-  
ate of copper & ??.

a) On the immediate line  
of this fault there is more evidence of  
metamorphism of the strata that has been  
seen from the Archean up to the summit  
of the Paleozoic series in the Colorado Canon  
district. The action causing this metamor-  
phism appears to have been Pre-Tertiary.

S. 1  
S. 2  
The amygdulæ in the upper portion of  
the lava flows & also that of the base of some



of them are coated with a green deposit 95.  
which sometimes fills the entire cavity.  
(Angite?) The amygdaloid structure  
is owing to the contact of the surface of the  
flows with the air or water probably the  
latter.

1/28/83

Hevorian on Temple Butte, Grand  
Canyon.

The Cambrian terminates below  
in a hard compact gray limestone, the  
base of the Red Wall limestone at this  
point, tho' elsewhere the Hevorian &  
upper hard beds of the Lonto unite  
with the Cambrian in the Red Wall  
cliff.



The Devonian is a little broken up at (96)  
the summit, for two or three feet in places,  
and a greenish clay holds the angular  
fragments.

Dana.

1.

Thin ~~beds~~ of dead colored ~~fine~~ grained l.  
with a little interbedded purplish sd.  
8 ft

2.

Rough calciferous sd in 3 massive  
layers each having a thin layer of  
purplish sandstone at the base  
22 ft

3

A more calcareous layer ~~of~~ with  
fossils. Anthis, Atrypa Murchisoni.  
4 "



97  
4. Shot at the character of 2. carry the section down about 30 feet when the sandstone over a coarse matter predominates over the calcareous & continues down to a somewhat arbitrarily drawn base as the massive Luto layers are conformable & resemble the Devonian.

46 ft.

Total Devonian 80 feet.

80 feet below the greenish calcareous beds of the Luto are met with & Luto facies run up about 25 feet. If a strong plane of erosion did not occur in the Kanab canyon between the Luto & the Devonian I should think from this section that one



were passing up thro' a conformable of (98).  
unbroken series of beds. The line as drawn  
is probably correct as the only well defined  
break of bedding occurs there.

S? The uniformity of the plane of erosion  
beneath the Tertiary elevation. Permian  
& Shinarump conglomerate along  
long lines of clean exposure is surprising  
& were it not for the occasional depressions  
on cliffs we would have but little  
evidence of the existence of such  
a plane of erosion.



1/30/83

By ascending the point on the south 94  
side of south Cuvar outlet is 1400+  
feet above the river - at the summit of the  
Lato cliff. A Chua lava hill 1250 -

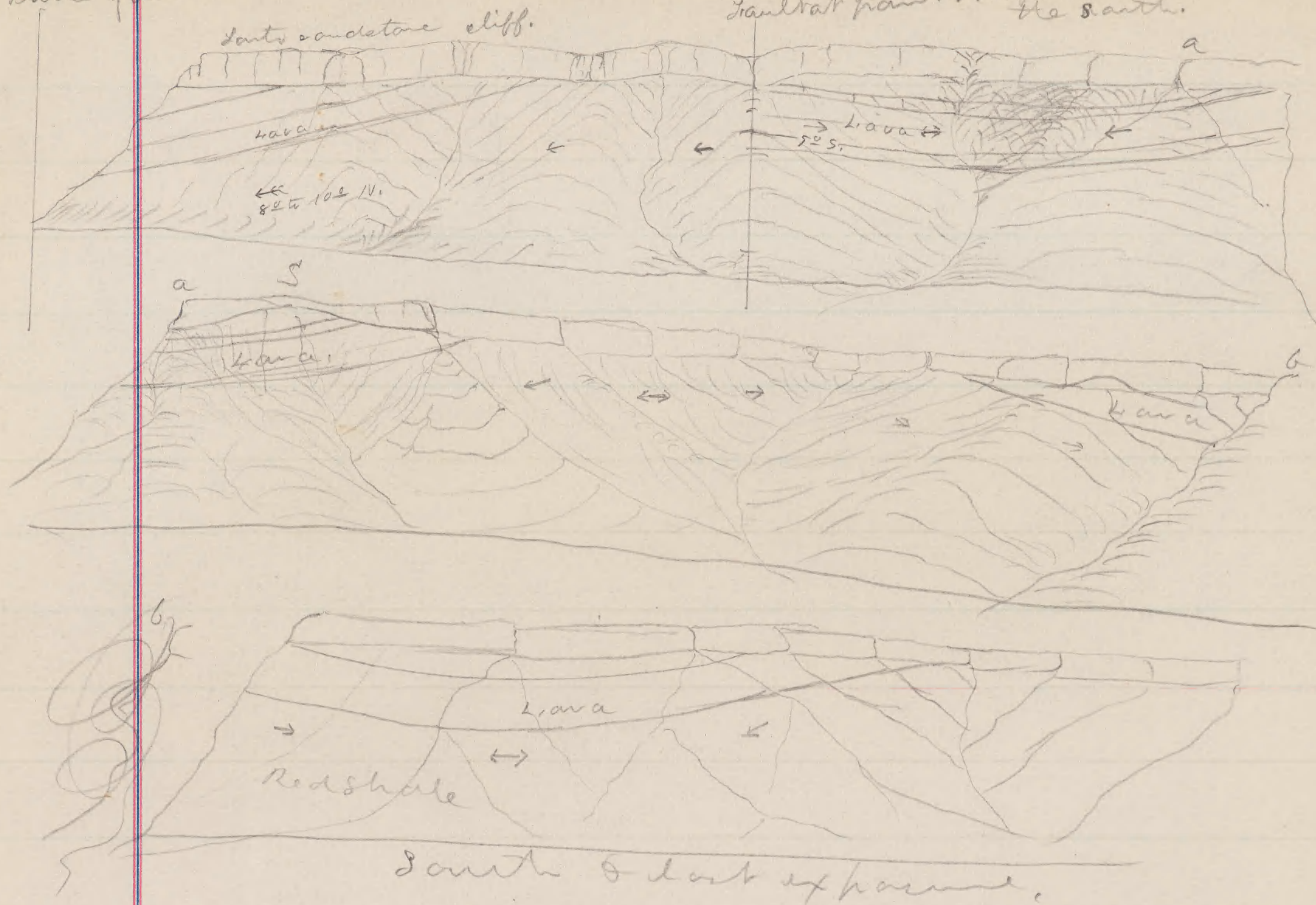
Base of Lato on south ridge 1400 feet  
above camp = 1625 above river. This is  
at the east butte on the Lato cliff, a  
mile to the west the Lato base  
is 3 to 400 feet higher.

From the east point of this ridge  
a sweeping view is obtained of the  
strata below the Lato on the  
east side of the river.



Butte fault.

X  
Lauriat point. 400 feet downthrow to the south. 100.

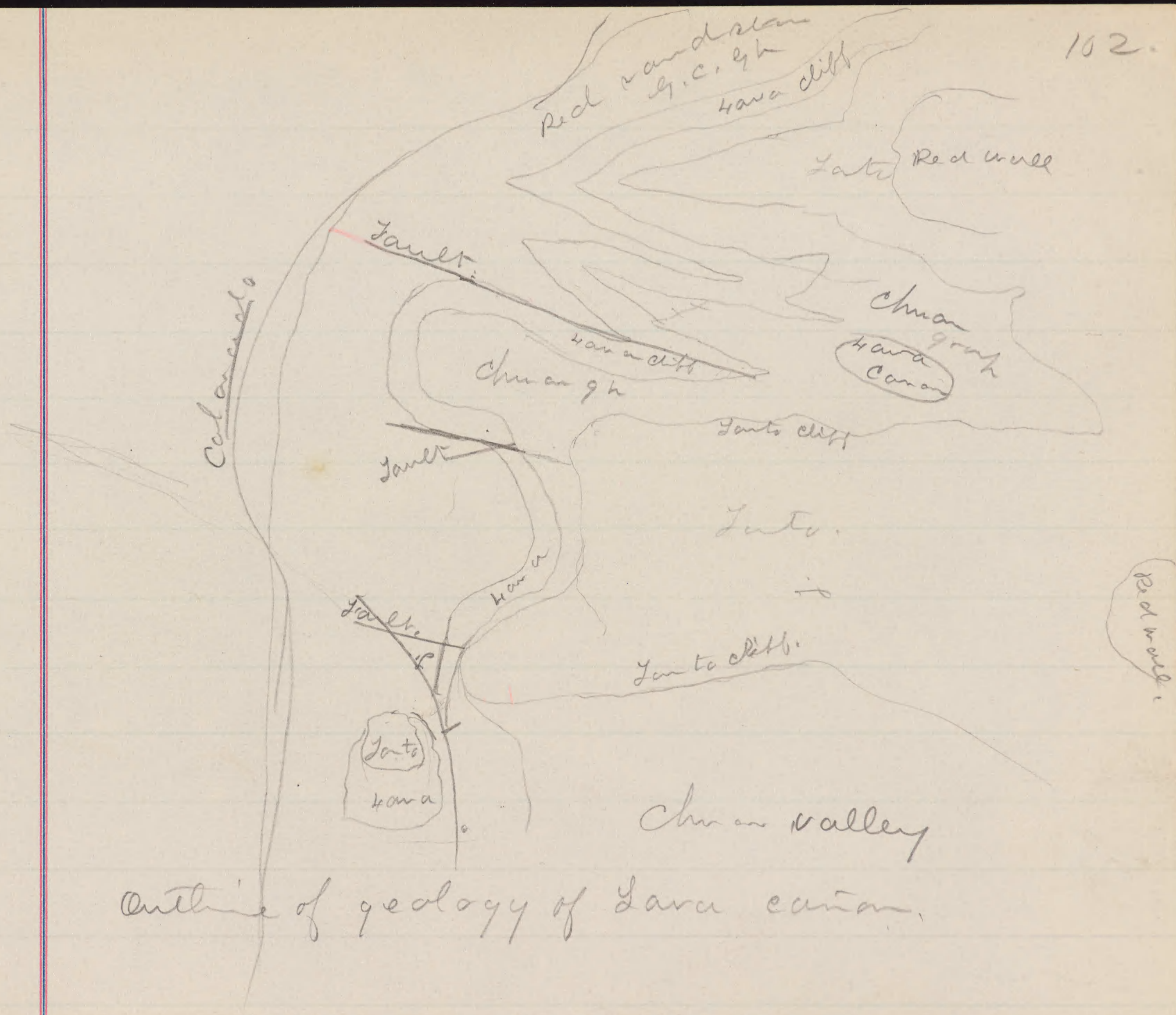


The fault at X has not hitherto been determined altho suspected



Its trend is N. 60° W. & it crosses the  
~~summit~~ passing beneath the ridge on  
 the south of Chuan valley just south  
 of the ~~divide~~ saddle at the east end  
 of that ridge. This brings the lava beds  
 in sight again & at S. the entire section  
 of the lava beds is seen with red shales  
 at summit as on the west side of the  
~~summit~~. The broad undulation of the  
 strata cut out ~~at~~ <sup>bring</sup> in the lava beds  
 are none on the south as has already  
 been noted. The fault line X was pre-  
 sent in greatest ~~thru~~ <sup>thru</sup> but it also shafted a  
 450 in the Kaitab mountain. The north side  
 going down.





Outline of geology of Lava canyon.



Pre-Lantz faulting

All along the Pre-Lantz fault the  
down throw is to the west on S.W. side of  
the fault. The two faults near  
lava cut - (see p 102) appear to be  
local & could not be traced far.

Lantz sandstone.

S<sub>1</sub> Noticed red sandstone pebbles that appear  
to have been derived from the Grand gray  
sandstones beneath.



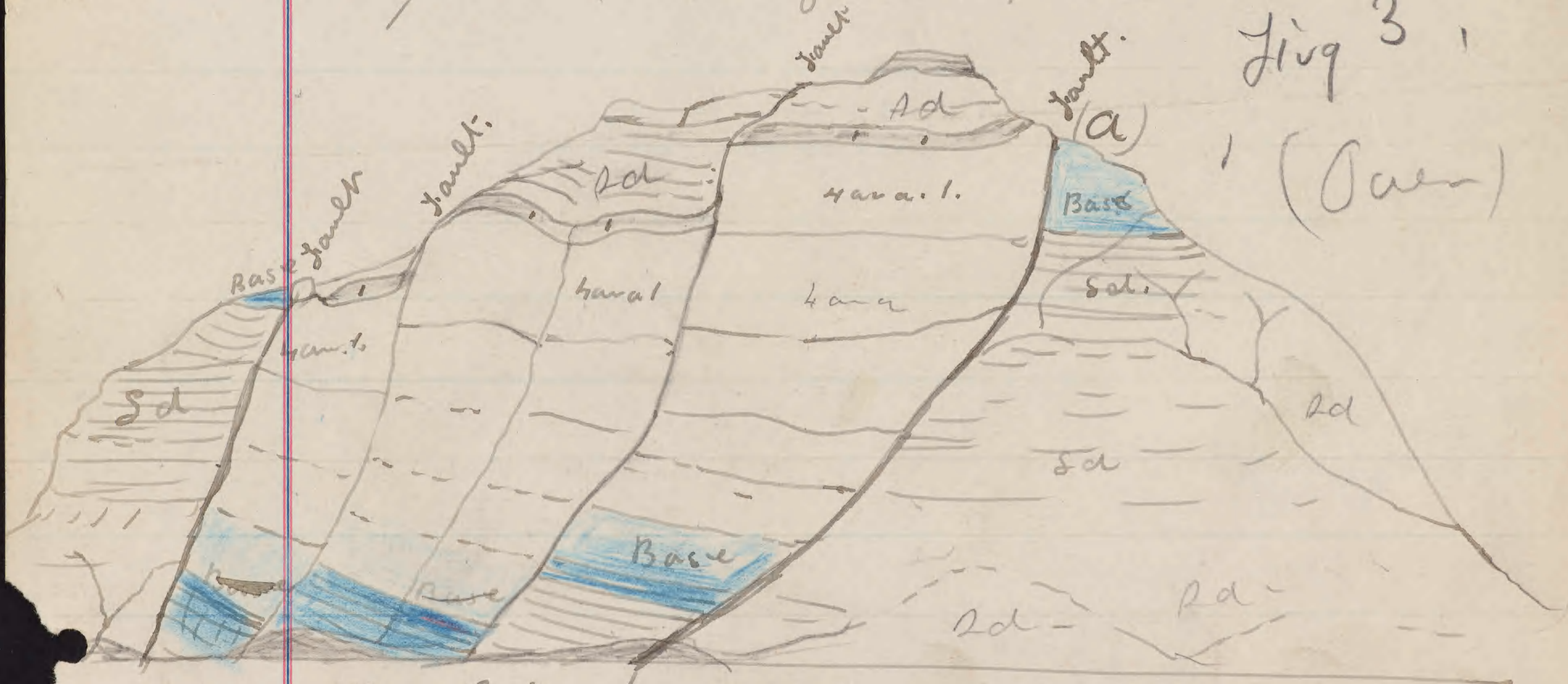


2/1/83

104

a little north of the outlet of Laramie  
Canyon a double fault lets a block  
of the lava cliff down to the water  
edge. Section of S.E. face.

Fig 3  
(over)



River shown.

The main fault on the north (A) has a down  
throw to the south of about 700 feet. The



Blue = sandstone,



The original lines of bedding of the <sup>105</sup>  
sandstone between the lava flows are  
somewhat bent & twisted but six flows  
can be distinctly seen on the right  
(north) side. The block is broken by  
3 minor faults before the south fault  
that dropped the block is reached.

The block faces the great open cañon  
on the east side of the rim but  
the lava there is a mile or more  
back from the rim & has not been  
dropped by faulting. From this point  
(south fault) the lava bed continues  
on around into lava cañon. (See  
authentic sketch of lava cañon. The



structure of this section disposed of the  
last of Powell's canons or valleys filled  
with lava. That of Nun-Ko-weoh  
being faulted up over 5000 feet &  
the red sd on top of it is Grand Canon  
group & not Lento.

S.S. / Data for section.

Three open or valley-like canons occur between  
Huron & Kewagunt valleys, the Lento having  
cliff nothing there except on the east where  
the Red wall is on Lower Aubrey sd, on  
both from a wall thro' which each  
has a narrow canon that descends  
rapidly to the river. The little fault  
line crossing just above the entrance  
to these canons. The canon valleys are



at their

<sup>lowest point</sup> about 700<sup>+</sup> feet below the <sup>level</sup> ridges of (107)  
the Lonto sandstone that separate  
them from each other & Chua &  
Kua-gant valleys respectively on the  
north & south. The Lonto cliff

forms the <sup>sides & head</sup> ~~rim~~ of each & extends down  
3 to 400 feet usually as a cliff, breaking  
down at the upper end & near

the little fault line. Below  
the Lonto the clays, sandstones &  
limestones of the Chua group are seen  
except where marked by the debris  
of the Lonto & Red Wall & the latter  
encircling around the head of each

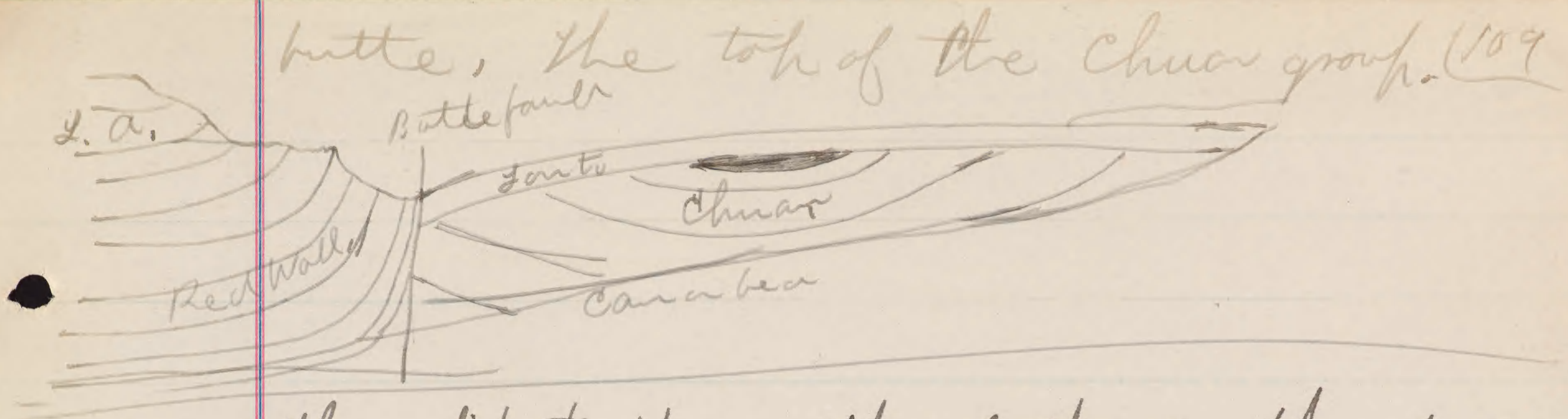
(a canyon as sheer cliff, breaking only  
as measured by aneroid)



a little at the points jutting out W8.  
on the Lato ridges.

In the most southern of the 3 canyons  
the <sup>strata of the</sup> Chuar group ~~strata~~ strike  $N45^{\circ}E$ ,  
dipping west  $45^{\circ}$  on the S.E. side, land  
down towards the little fault line. This  
dip ~~rapidly lessens~~ to the west of  
the beds are horizontal in the  
upper portion of the open canyon.  
(See sketch of south side of this canyon  
pg. ). Passing under the Lato ridge  
the beds seen on the south side show  
in the next canyon ~~as~~ a synclinal  
structure and are the  $\frac{1}{2}$  same as  
those capping Num-Ko-neah





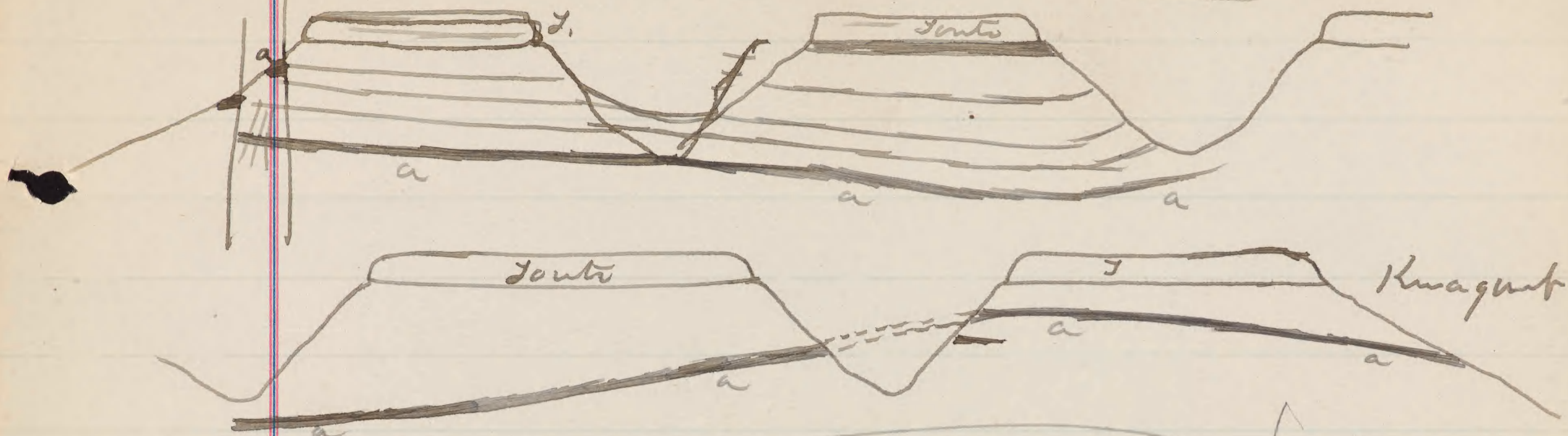
Chuao beds.

The dip to the south of the north edge of these beds carries them up to the <sup>Base</sup> fault line of erosion & they do not appear again except in the synclinal capping Mun-Ko-weap butte. The interval between this & the next or most northerly of the 3 cañons is broad & as debris largely covers the Chuao group in the latter it is difficult to trace the direct section but from the data obtained it appears to be ~~as~~ in the following sketch—



fault, Lechar from Chuan north.

110.



Correct as to distance depth of cañon  
etc by map. General plan of structure  
shown only.

Readings of Aneroid barometer.

Lower camp Chuan valley,	4000.	2d Cañon North,
1st divide North	6250.	estimated to be
" Cañon at bottom. w. fault.	5550.	700 feet deep at
2d divide, North.	6200.	lower end.
3d Cañon " Bottom.	5500.	
Huagunt divide	6200	
" " Camp	4750.	



2/10/83

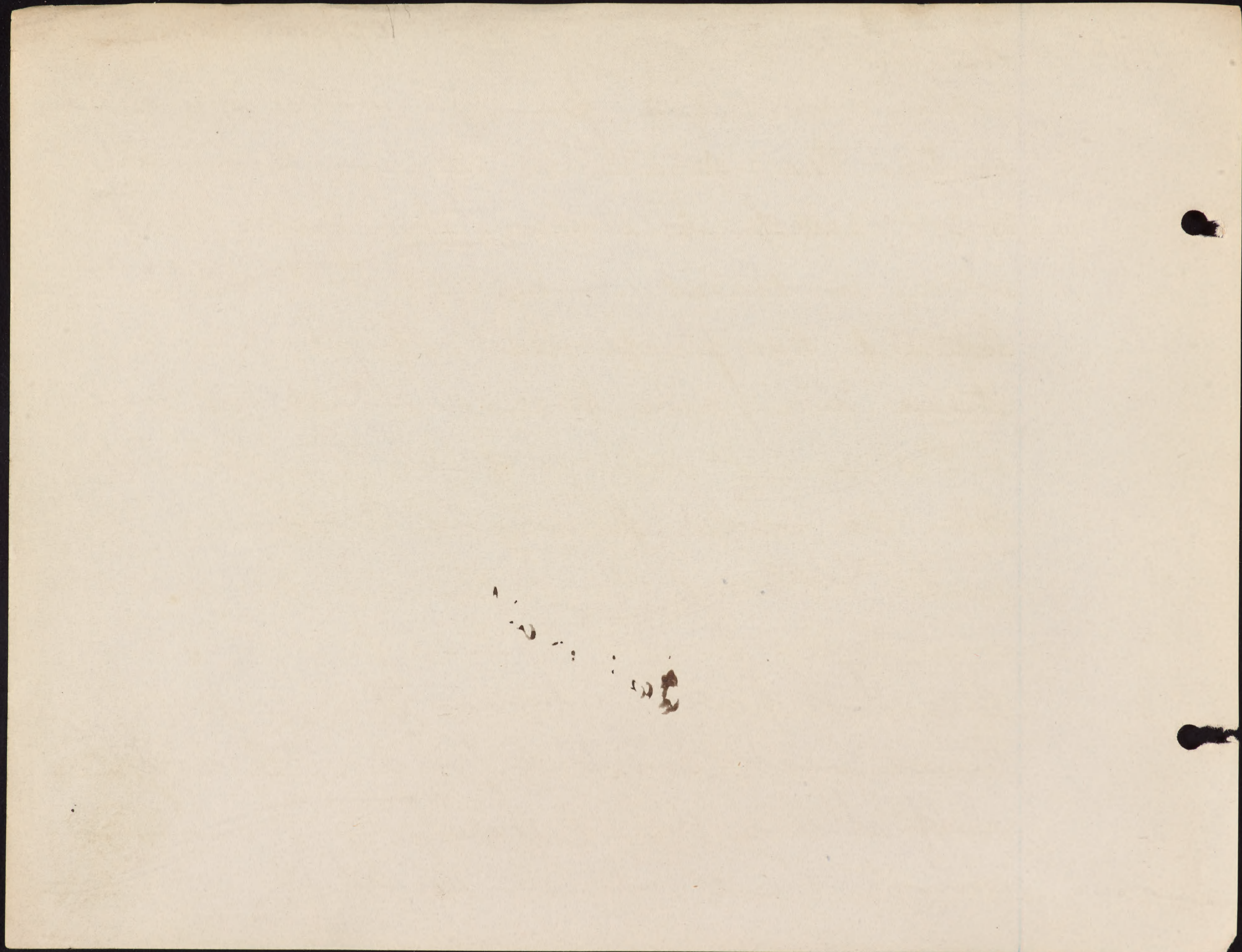
The eastern knob is small opposite Home (111)  
Rock valley rises from the valley in a curve  
of about  $10^{\circ}$  to  $15^{\circ}$  & then a level or gently  
rising slope of two or three miles leads  
up to another mine.

H.R. Valley

at the north end of Pagump-valley  
these two folds are united in one  
as also at the saddle  
at the head of trail Canon.

at the point where the river  
turns west thro' the fold the south  
cliff shows the same  
structure continues south,

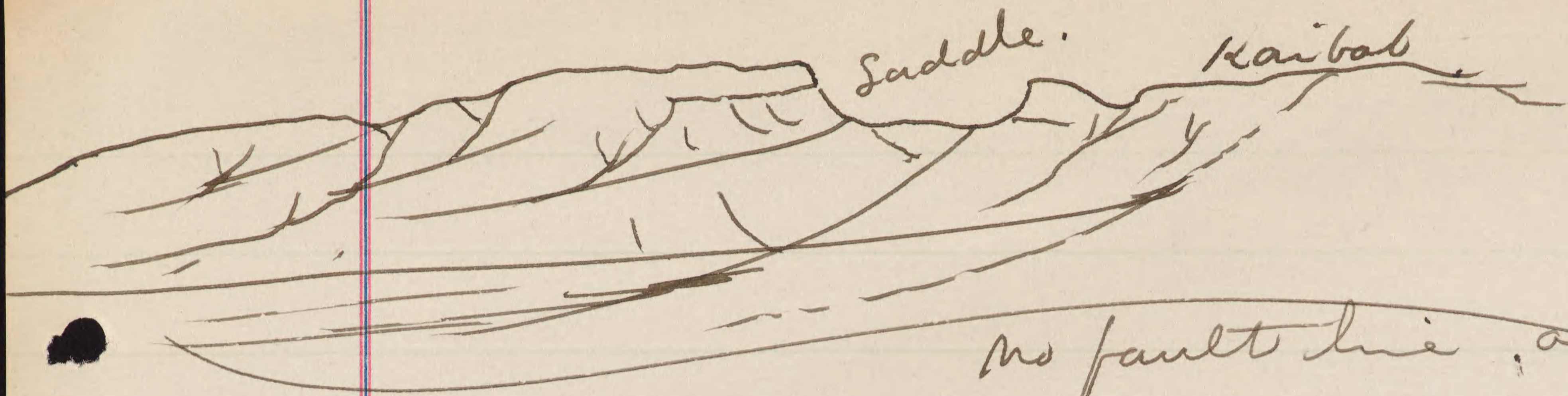






The trend of the fold along Horse Rock (112 valley is N & S. but where the two folds unite the direction changes to south  $25^{\circ}$  to  $30^{\circ}$  east. It is along this that Pa-gump valley is eroded. Except that the eastern buttes of Pa-gump dip rapidly  $15^{\circ}$  east there is a resemblance in its topography to the inner valleys of the Grand Canyon Nam-Ko-weap, Ku-a-gunt & Chuan. The great buttes of the latter = the small ones of the former & the drainage channels between them & the saddles heaping Pa-gump on a north and south line also finding their counterpart only on a greater scale.





no fault line, all a fold



N. B. N 7.

h. 2-3- ✓

" 4. ✓

" 6-10- ✓

" 17-27+ ✓

" 34. X also on sep. sheet. after Nov 28- h 34-36 ✓

" 36-38 + continue section one line of h 44-47 ✓

" 41-44 + continued on p 49. 52 ✓

" 47-48- Note on Num. Ho-ne-h Butte. ✓

" 59- Note on tracks etc. ✓

" 61. When half a hg. ✓

" 61. Note on fossils ✓

~~60.~~ 61. bottom of page to p. 64. ✓

" 64. Note on boulders. ✓

" 64-65. " " Into. ✓

" 66-71. ✓

" 72. ✓

" 74-78 ✓

" 79-87 ✓



Note Book 7.

Leontomiferous

h 4 . 6-10 . 17-27-

Nov. 30<sup>th</sup>

h 36.

hh 41-44. to line - continue

add note on h 60

on h 49. Dec 4<sup>th</sup>

49-52

~~add note on 1~~

Pattern of h 61 - (Dec. 9) to top 64

h 66 (Dec 12) to line 68

h 69 (Dec 15) - 71

hh 72 - (Head starts Dec 20)

82.